Alberta

MUNICIPAL AFFAIRS

Innovative Housing Grants Program

OPTIMUM VALUE ENGINEERING

August 1988

Richard J. Vanderwell, B.E.S., M. Arch.
Richard J. Vanderwell Architect Ltd.

The views and conclusions expressed and the recommendations made in this report are entirely those of the authors and should not be construed as expressing the opinions of Alberta Municipal Affairs.

ISBN: 0-88654-277-8

FOREWORD

The project documented in this report received funding under the Innovative Housing Grants Program of Alberta Municipal Affairs. The Innovative Housing Grants Program is intended to encourage and assist housing research and development which will reduce housing costs, improve the quality and performance of dwelling units and subdivisions, or increase the long term viability and competitiveness of Alberta's housing industry.

The Program offers assistance to builders, developers, consulting firms, professionals, industry groups, building products manufacturers, municipal governments, educational institutions, non-profit groups and individuals. At this time, priority areas for investigation include building design, construction technology, energy conservation, site and subdivision design, site servicing technology, residential building product development or improvement and information technology.

As the type of project and level of resources vary from applicant to applicant, the resulting documents are also varied. Comments and suggestions on this report are welcome. Please send comments or requests for further information to:

Innovative Housing Grants Program
Alberta Municipal Affairs
9925 - 107th Street
Edmonton, Alberta
T5K 2H9

Telephone: (403) 427-8150

ACKNOWLEDGEMENTS

The author would like to express appreciation to the Research and Development Section of Alberta Municipal Affairs for the financial assistance provided for the Optimum Value Engineering Study. In particular, thanks are extended to Mr. Ian Bazley for his initial interest, ongoing support and critical inputs into this study.

Special thanks to Mr. Adrian Rootsaert for his valuable contributions to the study. His broad experience in matters related to wood-frame housing and construction technology are most appreciated.

The study has also greatly benefited from the comments and insights provided by various construction contractors and tradespeople, as well as input from representatives of provincial and local construction associations. Their practical and timely advice in the areas of cost and materials estimating and their broad construction experience were invaluable.

Finally, the author wishes to acknowledge the broad base of research work completed to date on the subject of Optimum Value Engineering by such groups as the American National Association of Home Builders (NAHB) Research Foundation Inc. and the American Plywood Association.

TABLE OF CONTENTS

		Page No.
	LIST OF TABLES	iv
	LIST OF FIGURES	iv
	EXECUTIVE SUMMARY	v
1.0	INTRODUCTION: OPTIMUM VALUE ENGINEERING (OVE)	
	1.1 Why OVE?	1
	1.2 The Origin of OVE	2
	1.3 OVE Techniques for Alberta Builders	3
	1.4 Where to Start	5
	1.5 How this Study is Organized	6
	1.6 Where Information was Collected	8
	1.7 Limitations of the Study	9
	1.8 OVE Checklist	10
2.0	OVE TECHNIQUES RELATED TO TRADE DIVISIONS	
	2.0. INTRODUCTION	11
	2.1 FOUNDATIONS	
	2.1.1 Preserved Wood Foundations	13
	2.1.2 Engineered Concrete Foundation Design	15
	2.1.3 Floor Slab Thickness, Reinforcement, & Finishing	17
	2.2 SIDING	
	2.2.1 Combined Exterior Wall Sheathing/Siding	19
	2.3 ROOFING	
	2.3.1 Attic Venting	21

TABLE OF CONTENTS

Page No.

2.0 OVE TECHNIQUES RELATED TO TRADE DIVISIONS

2.4 CARPENTY - ROUGH

2.4.1	General OVE Framing Guidelines	23
2.4.2	OVE Floor Framing	25
2.4.3	OVE Wall Framing	27
2.4.4	Optimum Joist Length and Beam Location	29
2.4.5	Cantilevered Floor Areas	31
2.4.6	Single Layer Floor Sheathing	33
2.4.7	Elimination of Joist Bridging	35
2.4.8	Supporting Non-Loadbearing Partitions	37
2.4.9	OSB and Plywood I Joists	39
2.4.10	Laminated Ply-Beams	41
2.4.11	Drywall Clips	43
2.4.12	Partition Framing - Non-Loadbearing	45
2.4.13	Framing Coordination of Exterior Openings	47
2.4.14	Framing of Interior Openings	49
2.4.15	Accurate Header Selection	51

2.5 CARPENTRY - FINISH

2.5.1	Exterior Finish and Trim	53
2.5.2	Roof Trim Details	55
2.5.3	Reduce Interior Door and Window Trim	57
2.5.4	Closet Doors and Trim	59

TABLE OF CONTENTS

		Page No.
2.0	OVE TECHNIQUES RELATED TO TRADE DIVISIONS	
	2.6 PLUMBING	
	2.6.1 Centralized Plumbing	61
	2.6.2 Reduced Drain & Vent Pipe Venting	63
	2.6.3 Fibreglass Bath Modules	64
	2.6.4 Eliminate Fixture Supply Valves	65
	2.6.5 Alternative Plastic Water Supply Piping	66
3.0	COMPARATIVE HOUSE COSTS	
	3.1 Why Three Houses?	70
	3.2 Scope of Comparision	71
	3.3 Alberta House Cost Comparison	72
	3.4 OVE 1 - AHCC Design	80
	3.5 OVE 2 - Prototype Design	88
	3.6 Cost Comparison Summary	100
	3.7 Statistical Comparisons	102
4.0	CONCLUSIONS	103
	BIBLIOGRAPHY	106

LIST OF TABLES

		Page No.
Table 1:	Summary of Individual OVE Techniques and Applicable Cost-Savings	68 & 69
Table 2:	Optimum Value Engineering: Cost Comparison Summary	101
Table 3:	Statistical Comparisons: AHCC, OVE 1, and OVE 2	102

LIST OF FIGURES

		Page No.
Figure 1:	AHCC Isometric	74
Figure 2:	AHCC Ground Floor	75
Figure 3:	AHCC Basement Plan	76
Figure 4:	AHCC Front Elevation	77
Figure 5:	AHCC Rear and Side Elevations	78
Figure 6:	AHCC Section	79
Figure 7:	OVE - 1 Isometric	82
Figure 8:	OVE - 1 Ground Floor	83
Figure 9:	OVE - 1 Basement Plan	84
Figure 10:	OVE - 1 Front Elevation	85
Figure 11:	OVE - 1 Side and Rear Elevations	86
Figure 12:	OVE - 1 Section	87
Figure 13:	OVE - 2 Isometric	92
Figure 14:	OVE - 2 Main Floor	93
Figure 15:	OVE - 2 Second Floor	94
Figure 16:	OVE - 2 Front Elevation	95
Figure 17:	OVE - 2 Rear Elevation	96
Figure 18:	OVE - 2 Basement Plan	97
Figure 19:	OVE - 2 Section	98
Figure 20:	OVE - 2 Growth Scenarios	99

EXECUTIVE SUMMARY

This study documents the results of research into Optimum Value Engineering (OVE), a project funded by Alberta Municipal Affairs under the Innovative Housing Grants Program.

The purpose of this study is to research and document current cost saving construction techniques, to provide a cost analysis of the most promising, and finally, to provide a compilation of construction systems and measures available in the Alberta marketplace to builders and consumers. Whether used selectively or as a total approach, OVE techniques will easily adapt to housing of all types and styles.

Research into conventional wood-frame design and construction technology shows that there has been only marginal innovative change taking place in the area of efficient use of labour and materials over the last 20 years. There are numerous examples of materials and labour wastage which can be attributed to a perceived need for added structural rigidity or for assumed code compliance. In many cases the additional inputs of labour and materials serve no purpose and end up adding appreciably to the cost of a project. Directly or indirectly, it is the housing consumer who must finally bear the extra cost. Recent increases in construction costs makes it increasingly important that we develop methods of using our labour and resources more efficiently in the production of housing.

OVE is a procedure of comparing alternative materials and methods to determine the least costly combination that will result in an acceptable market product. OVE is not a collection of unrelated cost-cutting or quality-cutting ideas. It is a new approach to an old problem: how to utilize both labour and material resources efficently in construction. The answer is found in the intelligent use of available building materials, labour skills, tools and equipment. Home builders regularly practice a form of value engineering when they select house designs, materials, and products that represent the least costly, marketable combination in their judgement.

The OVE structure is based typically on a 600mm (24") construction module, in which the placement of the aligned framing members of floors, walls, and roof define the basic architectural components of the house. Simplifying construction techniques to conform to the module, and using sound engineering practice, less material and less labour results in a more easily constructed and less expensive home.

Part one of the study reviews in detail the OVE techniques available to Alberta builders. It describes the new technique, what it replaces, and what it saves. Further discussion pertaining to code issues and builder and trade reactions and other comments, follow each technique. Individual cost-saving techniques propose in the study offer the average home builder a "shopping list" approach to OVE. By investigating, evaluating and trying one or more of the techniques, a builder can gradually ascertain which of the measures is applicable to his own particular scale and style of operation. As OVE techniques form an integrated method of building, maximum benefit is realized when they are used together. Nevertheless, many individual OVE methods can be integrated with conventional wood framing practice, resulting in some significant cost savings.

The second part of the study deals with cost comparisons of three single-family houses. The first house is the AHCC or "base" design, based on the model used in the annual Alberta House Cost Comparison Study (AHCC), having no OVE measures applied to it. The second comparison house, the "OVE 1 - AHCC DESIGN," is of the basic AHCC design, but with many OVE-related measures applied to it. The size, layout, and external shape remain essentially the same as the original AHCC design. The third house, the "OVE 2 PROTOTYPE," was conceived and designed as an OVE house utilizing a greater number of the researched cost-saving techniques. The research into OVE and non-OVE houses allows individual cost inputs into each to be analyzed, compared and contrasted. Research showed that OVE techniques applied to a conventional house can effect a total cost saving of approximately ten percent.

If buildings can be initially designed to include and maximize OVE techniques, cost savings should be much greater than if techniques are just applied to an existing stock house design. An added benefit to an all-OVE based design, such as the OVE 2 Prototype house, is that design quality and market appeal can be enhanced, at the same time as cost saving measures are being applied by a builder. There is greater potential for benefits to be passed on to both the builder and the home buyer in such a situation. In the case of the OVE 2 Prototype house, it would be possible to build a larger, better designed and more appealing house for approximately the same cost as a non-OVE house. In today's competitive market the builder must provide an excellent product at reasonable cost; OVE can help this happen.

1.0 INTRODUCTION: OPTIMUM VALUE ENGINEERING (OVE)

1.0 INTRODUCTION: OPTIMUM VALUE ENGINEERING (OVE)

1.1 Why OVE?

The purpose of this study is to research and document current cost saving construction techniques, to provide a cost analysis of the most promising, and finally, to provide a compilation of construction systems and measures available in the Alberta marketplace to builders and consumers.

Optimum Value Engineering (OVE) is a procedure of comparing alternative materials and methods to determine the least costly combination that will result in an acceptable market product. It is a new approach to an old problem: how to utilize both labour and material resources efficently in construction. The answers are found in the use of available building materials, labour skills, tools and equipment.

OVE can result in a systematic approach to significant cost savings in wood-frame construction. OVE techniques include general planning and design concepts; construction and framing construction and detailing methods, final architectural finishing and detailing, and new approaches to plumbing, heating, and electrical systems. In today's competitive market the builder must provide an excellent product at reasonable cost; OVE can help this happen.

1.2 The Origin of OVE

OVE was first developed in the United States by the National Association of Home Builders (NAHB) Research Foundation Inc. as a system designed to reduce the building costs of homes. It is an engineered approach to building based on both available building materials and labour skills. While the original research was done more than ten years ago, many of the techniques are certainly worth considering in today's construction marketplace.

Rather than focus on an unrelated collection of cost-saving building techniques, the NAHB Research Foundation chose to integrate a series of planning, engineering and construction techniques that complement each other. In addition to researching and identifying potential cost-saving techniques, the costs of labour and materials alternates were also analysed and compared.

NAHB used a prototype design of a single-family detached house (88.4 sq. m). Detailed costs of labour and materials were kept and compared to a conventionally built house. It was found that the OVE house had achieved a total cost saving of approximately 12%. In addition to significant cost savings on a strictly OVE-designed house, it was found that the OVE system could be easily adapted to other housing types and styles.

The NAHB prototype consisted of a single storey rectangular house on a crawl space foundation. The facilities included one bathroom, a compact utility room, and an efficient kitchen with a shared plumbing wall. While this type of house design may have minimal application or appeal in the current Alberta marketplace, it does serve to illustrate some of the potential of cost-saving OVE techniques in another geographical setting. The Alberta experience normally demands such basic features as full basements, ample heating systems and higher levels of insulation, air tightness, and ventilation.

The OVE structure was based on a 2' construction module, in which the placement of the aligned framing members of floors, walls, and roof define the basic architectural components of the house. Simplifying the construction techniques to conform to the module, and using sound engineering practice, less material and less labour resulted in a more easily constructed and less expensive building.

1.3 OVE Techniques for Alberta Builders

For the most part, OVE measures have never been properly presented to home builders or buyers. Incentives and pressures to bring about lower costs for housing have always been present, but there has never been an organized, systematic approach to the problem. Cost-saving measures have been introduced to the Alberta marketplace over time, but in a mainly disjointed fashion.

Change in the construction industry has traditionally occured slowly and cautiously, and only when specific benefits could be identified, for either the builder or the home-buying consumer. New approaches to construction in Alberta have been evolutionary rather than revolutionary. Market acceptance of new methods or techniques must be preceeded by proven durability and long-term performance, rather than by overly optimistic product claims or inflated labour economies.

Alberta builders, like their conterparts in most jurisdictions, need a hands-on approach to understanding and trying the techniques and measures proposed by the OVE concept of construction. COST SAVING BUILDING TECHNIQUES PUT FORWARD USING THE OVE APPROACH MUST NOT BE EQUATED WITH "LOW QUALITY" BUILDINGS. Instead, OVE must satisfy the need for more economical and durable construction techniques that are systematic and complementary to each other.

Surveying home construction methods in the Edmonton area showed the industry does not often depart from conventional methods of materials selection and wood-framing techniques, and with its general approach to construction. This frequently means using much more construction material and labour than may be required by code, often for reasons of tradition or perceived added structural rigidity. General framing procedures and materials selection do not vary greatly among projects or builders.

For example, it was observed that, with few exceptions, door and window openings in walls were framed in with double or triple headers over all openings, regardless of whether the wall was load-bearing. When asked why, the typical trade response was that "it is required by code," or "it results in a stronger, better product." This practice alone accounts for significant extra framing labour and materials costs for the average house.

1.4 Where to Start

Since the OVE experience is new to the Alberta scene, many of the cost-saving measures will require a rethinking of many of the previous construction techniques for the average home builder. A number of the OVE techniques presented may not be appropriate for the entire Alberta marketplace or for all climatic applications; each technique must be evaluated on its own merits and in relation to other, related OVE and traditional construction techniques.

The framing trade in particular needs to understand the reasons that certain cost-saving techniques are feasible, and why the structural integrity of the finished product will not be sacrificed by the change. The challenge with promoting OVE is to prove that buildings in Alberta can be built more cost effectively and more efficiently, while working mostly with currently available inputs of labour and materials.

1.5 How this Study is Organized

This study is organized into two major parts:

Part 1

Part one reviews in detail the OVE techniques available to Alberta builders. It describes the new techniques, what they replace, and what they save. Further discussion pertaining to code issues and builder and trade reactions, and other comment, follow each technique. The order of presentation follows the trade division format already established by the Alberta House Cost Comparison (AHCC) study which is conducted annually by Alberta Municipal Affairs to compare costs of conventional construction throughout the Province.)

Individual cost-saving techniques proposed in the study offer the average builder a "shopping list" approach to OVE. By investigating, evaluating, and trying one or more of the techniques, a builder can gradually ascertain which of the measures is workable for his own particular scale and style of operation.

As OVE techniques are an integrated method of building, maximum benefit is realized when they are used together. Nevertheless, many individual OVE methods can be integrated with conventional wood-framing practice, and still result in some significant degree of cost savings.

Part 2

The second part of the study deals with cost comparisons of three single-family houses. The first house is the model used in the AHCC study, having no OVE measures applied to it. The AHCC house is a single-family, 100 sq. m bungalow with a full and open basement. The basic plan is rectangular in shape. The total heated volume, including the basement area, is approximately 480 cu. m. The house contains three bedrooms, a living room, combined dining space and kitchen, and a single bathroom. The quality of interior and exterior finishing is considered modest by today's standards. The AHCC house is used as a "base" or "bare bones" comparison model for two OVE houses.

The second comparison house, called the "OVE 1 - AHCC design", is of the basic AHCC design, but with many OVE-related measures applied to it. The size, layout, and external shape remain essentially the same as the original AHCC design. This allows a fair comparison of labour and material inputs for each of the first two houses.

The third house, the "OVE 2 - PROTOTYPE," was conceived and designed as an OVE house utilizing a greater number of the researched cost-saving techniques. This house provides nearly 12% more floor area than the other two houses. Since OVE innovation would have to compete equally in the Alberta marketplace with non-OVE housing, the OVE 2 Prototype has also been designed in response to specific and current Alberta market preferences and trends.

The labour and material cost inputs for each of the three houses have been calculated using current data and cost input from the 1986 Alberta House Cost Comparison Study, as well as costing advice from local house builders and budget estimates from related sub-trades.

1.6 Where Information Was Collected

The various NAHB published information manuals related to OVE cost-saving measures formed the starting point for this study. Other trade and special-interest construction publications were also researched and analyzed in terms of the Alberta experience.

The study also gained practical information and views on OVE from other sources. Informal interviews were held with a number of Edmonton area builders, tradesmen and the builders' construction association. Reactions to and opinions on OVE were collected and introduced into the study where appropriate, such as in Part 1, Technique.

1.7 Limitations of the Study

Many OVE techniques are workable in Alberta and are compatible with conventional trade practices. Some of the broad planning concepts espoused by OVE however, such as market-driven issues related to house design and layout, as well as other elements climatically determined, would in all likelihood meet with Alberta trade and consumer resistance.

Nevertheless, to effect constructive change within the Alberta construction industry, consideration should be given to lobbying for those changes which would prove beneficial to both the construction industry and the house buying consumer. The real success of an affordable housing approach like OVE depends upon builders, designers, government officials, and housing consumers taking necessary steps to encourage innovation in the marketplace.

Although the study costing information was specific to the Edmonton market, the relative benefits of OVE should be of interest to the reader who is familiar with conventional building techniques in other locations in the Province.

1.8 OVE
Checklist

OPTIMUM VALUE ENGINEERING IS:

- a procedure of comparing alternative methods and materials to determine the least costly combination;
- an effective and systematic total approach;
- a wide variety of cost-saving techniques compatible with wood frame construction;
- effective use of materials and labour skills;
- a series of cost-saving measures, integrated to work together and complement each other;
- the employment of techniques adaptable to on-site, shop, or prefabricated building methods.
- an approach to the planning, design, and engineering of residential construction;
- intended to produce maximum benefit when the total OVE approach is utilized;
- the use of individual OVE techniques compatible with conventional methods offering significant savings; and
- application of good judgement, sound building practices, and attention to good workmanship and quality.

OPTIMUM VALUE ENGINEERING IS NOT:

- a collection of unrelated cost-cutting or quality-cutting ideas.

2.0 OVE TECHNIQUES RELATED TO TRADE DIVISIONS

2.0 OVE TECHNIQUES RELATED TO TRADE DIVISIONS

INTRODUCTION

How to Use the OVE Work Sheets Work sheets were developed for each promising OVE technique researched. They were then generally arranged into the 22 part trade division format first developed for the Alberta House Cost Comparison Study (AHCC). This allows direct comparison of the trade and cost impacts of OVE techniques as compared with conventional construction. The work sheets also provide logical groupings that are often directly related to trade activities on site. Illustrations of the techniques are included where possible.

The New Technique The OVE technique is described in the first sentence of the work sheet to indicate what it is and how it fits into the home. Some techniques will group a number of similar cost-saving ideas together when convenient, such as in framing, plumbing or heating work.

What It Replaces The work sheets will describe practices or material being replaced. Where OVE techniques have an impact on other trades or have market implications, these will also be described.

What It Saves The relative costs of introducing promising OVE techniques are presented for most of the techniques.

Market Area/ Application

Issues related to trade and market acceptance of the technique are outlined where applicable. Where techniques vary from conventional practice, the relative merits are compared and contrasted.

Impediments/ Incentives to Usage

This section outlines the specific features of each OVE technique, how conventional construction or detailing might be modified or replaced, any reactions that may have been received from builders or tradespeople, and what, if any, effect the current Alberta Building Code (1985), may have on the technique.

Interviews conducted with builders and construction associations were structured in an informal fashion to elicit comments and suggestions for many of the OVE techniques and the OVE concept in general.

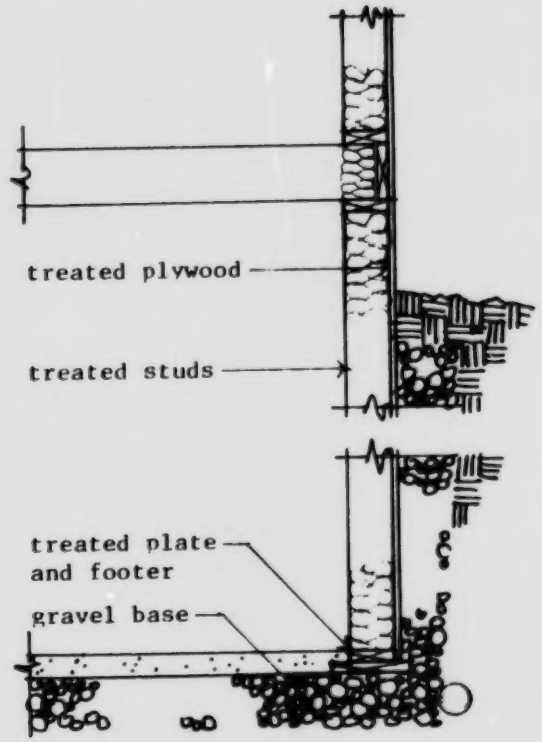
OVE TECHNIQUE: 2.1.1 PRESERVED WOOD FOUNDATIONS

DESCRIPTION & ECONOMICS OF ADOPTION

The New Technique:
- Preserved wood foundations (PWF).

What It Replaces:
- Conventional poured concrete basements with interior stud walls and insulation.

The Savings:
- With a PWF system, construction costs can be between $450 and $500 lower than with conventional concrete foundations.
- PWF walls provide more energy efficient insulating qualities than conventional concrete walls. And because they are substantially thinner, approximately 8 m^2 (86 sq. ft.) of basement floor area is saved.



Preserved Wood Foundation

HISTORY & TRADE EXPERIENCE

Market Area/ Application:
- Large numbers of preserved wood foundation projects have performed well in the Alberta marketplace over the past years. Market acceptance of the system has grown gradually, especially in the rural areas where concrete costs are high.
- At present, over 100,000 PWF systems have been installed in both Canada and the USA.

CURRENT IMPEDIMENTS/INCENTIVES TO USAGE

General:

- PWF systems must be designed and their construction supervised by an engineer which adds to the system cost.
- PWF basement walls are suitable for construction in cold climates such as Alberta and they have the added potential for prefabrication.
- Where a complete PWF system is utilized, concrete trade can be eliminated from the site.
- PWF basement walls can enhance below-grade living conditions. Electrical wiring is readily installed and higher RSI levels of insulation can be installed between the studs. Drywall can be screwed directly to the foundation wall system.
- Combination or composite systems of concrete and PWF have recently been introduced. Poured concrete footings, PWF walls, and poured concrete floors have gained acceptance.
- Market acceptance of combination systems is evident.

Trade Comments:

- The builder's own carpentry crews can install the foundation. Cold-weather construction can be accelerated with the use of PWF systems; delays caused by weather can be minimized.
- OVE planning at 610mm (2'-0") on centre for floor joists, upper wall studs, and roof trusses cannot be carried to the basement wall studs due to increased loads placed on the basement walls by soil pressures.
- Good drainage must be provided for the proper performance of a PWF system.
- Check the soil type, frost line, slope and drainage conditions of the site. Expansive clays and silts exert high loads on foundations. Ask the local building authority and if problems are expected consult an engineer.

Code References: ABC SUBSECTION 9.15.1.4. Amendments required to ABC 1985: ____ Yes __X__ No
CANADIAN STANDARDS ASSOCIATION: CAN 3-S406-M

Note: A special CSA Standard 080.15 has been written exclusively for the pressure treatment of PWF material. The standard calls for loading the wood with more preservative than normal. It also requires drying the material to 19% moisture content or below before shipment.

DESCRIPTION & ECONOMICS OF ADOPTION

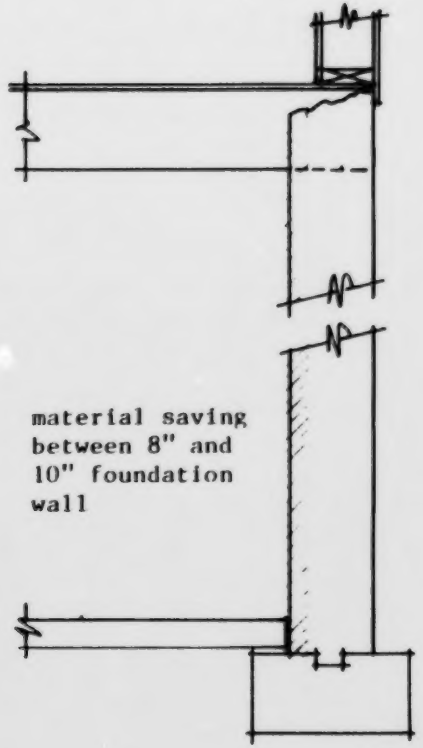
The New Technique: - Reduce the wall thickness and footing width and/or depth on larger developments where the soil condition is known.

What It Replaces: - Wall or footing sizes that are not related to actual site conditions.

The Savings: - A 200mm (8") foundation wall saves 20% of the material cost of a 250mm (10") wall. If allowed by code, this reduction in wall thickness could translate into a $200 to $250 cost savings on an average sized house.

HISTORY & TRADE EXPERIENCE

Market Area/ Application: - For larger developments, traditional methods of selecting foundations should be reviewed by a structural engineer to determine if reductions can or should be made.



Typical Foundation Wall

OVE TECHNIQUE: 2.1.2 ENGINEERED CONCRETE FOUNDATION DESIGN (cont.)

CURRENT IMPEDIMENTS/INCENTIVES TO USAGE

General:
- Poured concrete walls of 150mm (6") thickness may be adequate for strength and appear to meet minimum code requirements, but there is a concern that workmanship may not be consistent.
- Foundation walls reduced to less than 200mm (8") are not recommended.
- Reduced footing size and/or wall thickness could cause concern under conditions such as lack of proper site supervision or a lack of quality control.

Trade Comments:
- Footing or foundations reductions below code minimum would require engineering seals, and are therefore not recommended.

Code Reference: ABC SUBSECTION 9.15 Amendments required to ABC 1985: ____ Yes __X__ No

DESCRIPTION & ECONOMICS OF ADOPTION

The New Technique:

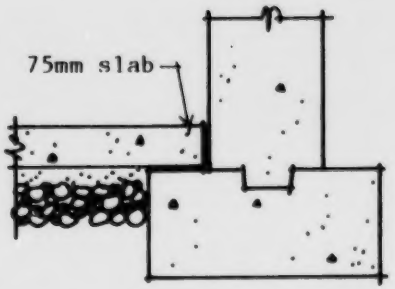
- A well-compacted and evenly spread granular base will normally allow the use of a 75mm (3") thick concrete pour for basement floor slabs.
- Welded wire mesh could be eliminated since it is of minor value in eliminating the width of cracks.
- Stubbing plumbing risers flush with the final slab elevation simplifies concrete floating and finishing.

What It Replaces:

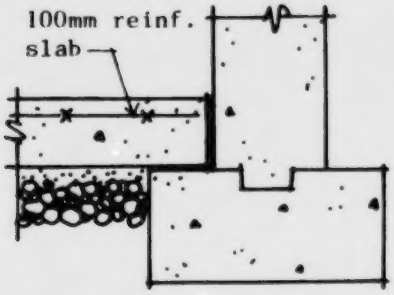
- Conventional basement slab pours are often as much as 100mm (4") in thickness and usually include the supply and installation of welded wire mesh.

The Savings:

- The potential material cost saving for the deletion of up to 25mm (1") of concrete is $200.00 on an average size house.
- The deletion of 100 m^2 (1,076 sq. ft.) of welded wire mesh results in a cost saving of approximately $80.00.
- The labour saving for stubbing plumbing risers flush with the floor slab is in the order of $25.00.



Reduced Slab Thickness/Reinf.



Conventional Slab/Footing

OVE TECHNIQUE: 2.1.3 FLOOR SLAB THICKNESS, REINFORCEMENT & FINISHING (cont.)

HISTORY & TRADE EXPERIENCE

Market Area/ Application:

- Conventional interior floor finishes such as carpet, resilient tile and sheet vinyl will normally cover shrinkage cracks that may appear in the floor slab.

CURRENT IMPEDIMENTS/INCENTIVES TO USAGE

General:

- As welded wire mesh is of minor value in eliminating the width and size of cracks, and it is seldom correctly installed, it provides no significant function.
- Properly placed control joints will help to localize cracks.
- A well-prepared and stable base will assure better performance from slabs under normal conditions.
- Concrete floating and finishing can be simplified by stubbing plumbing risers flush with the slab elevation. This practice can be difficult if final slab elevation has not been clearly established by the builder.

Trade Comments:

- Obtaining adequate compaction of the base is often difficult on site due to potentially adverse weather conditions.

Code Reference: ABC SUBSECTION 9.16.4. Amendments required to ABC 1985: _____ Yes __X__ No

DESCRIPTION & ECONOMICS OF ADOPTION

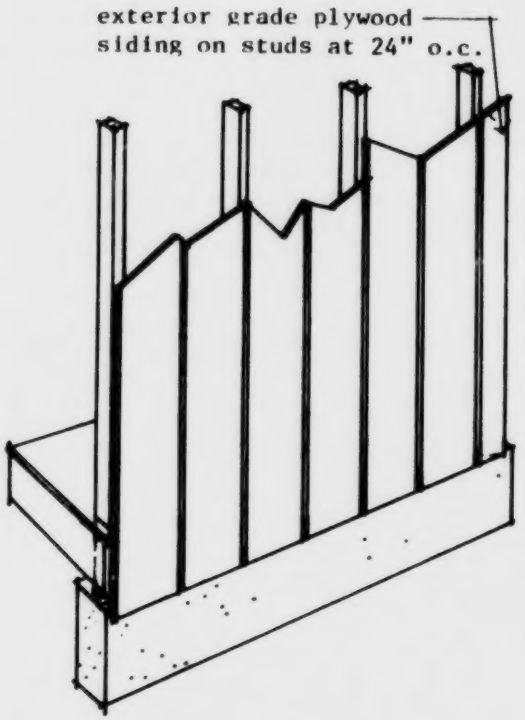
The New Technique: - Use exterior grade panel products as the exterior finish.

What It Replaces: - Conventional arrangement of sheathing and unfinished wood.

The Savings: - The potential material and labour cost saving for the substitution for panel-type siding products for an average size house is $300.00. This saving reflects the deletion of the exterior wall sheathing used in conventional construction.

HISTORY & TRADE EXPERIENCE

Market Area/ Application:
- Prefinished wall panel products are popular and can compete in price and performance with aluminum and vinyl products.
- Unfinished combined sheathing/siding may require additional maintenance and staining, unlike prefinished aluminum or vinyl siding but competes favourably with sidings which require painting or staining.



Plywood Sheathing/Siding

CURRENT IMPEDIMENTS/INCENTIVES TO USAGE

General:
- Structural siding products installed directly to studs combine the functions of siding, sheathing and structural bracing in a single layer.

Trade Comments:
- More care is required with the installation of panel siding to ensure damage does not occur during erection of subsequent floors and roof components.
- It is recommended the sheathing and/or siding be applied to the wall framing before the wall is tilted up. Most siding products can be installed in this manner, especially with full-length walls.

Code Reference: ABC SUBSECTION 9.23.16-18 Amendments required to ABC 1985: _____ Yes __X__ No

OVE TECHNIQUE: 2.3.1 ATTIC VENTING

DESCRIPTION & ECONOMICS OF ADOPTION

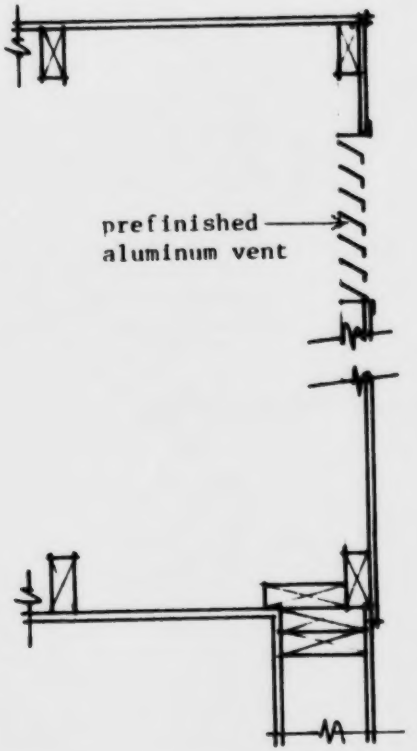
The New Technique: - Provision of vents in the gable ends of walls is the least costly means of providing attic ventilation.

What It Replaces: - Soffit venting along the roof eaves is widely used in the province and usually consists of perforated, prefinished aluminum panels, stapled to the underside of roof trusses.

The Savings: - The potential material and labour cost saving for the deletion of insulation stops, and extra time required for the conventional placement of insulation is in the order of $65.00.

HISTORY & TRADE EXPERIENCE

Market Area/ Application: - With higher levels of attic insulation being installed and tighter sealing of air barriers, there is less emphasis being placed on the amount of attic venting being required. Venting, however must still comply with current code requirements.



Gable End Attic Venting

CURRENT IMPEDIMENTS/INCENTIVES TO USAGE

General: - Venting is intended to avoid the build-up of excessive heat or moisture.

Trade Comments:
- There is a structural concern in the cold Alberta climate where lower moisture content in the attic will help to reduce truss jacking in cold weather. Good sealing of the ceiling air barrier combined with adequate attic ventilation should help to reduce this problem.
- Gable end vents, if properly sized and located, should provide the amount of attic venting required by the ABC 1985. Improved venting performance should also be expected from properly located gable vents, as compared to conventional soffit vents, which rely solely on convection air movement.
- Less material and labour are required to install gable end vents than insulation stops and special cutting required for soffit or roof ridge venting.

Code Reference: ABC SUBSECTION 9.19.1. Amendments required to ABC 1985: ____ Yes __X__ No

OVE TECHNIQUE: 2.4.1 GENERAL OVE FRAMING GUIDELINES

DESCRIPTION & ECONOMICS OF ADOPTION

The New Technique:

- Build with all framing on a 600mm (24") basis. Typical OVE floor, wall, and roof details are provided for further reference in the pages following this section.

What It Replaces:

- Conventional framing at 400mm (16") centres.

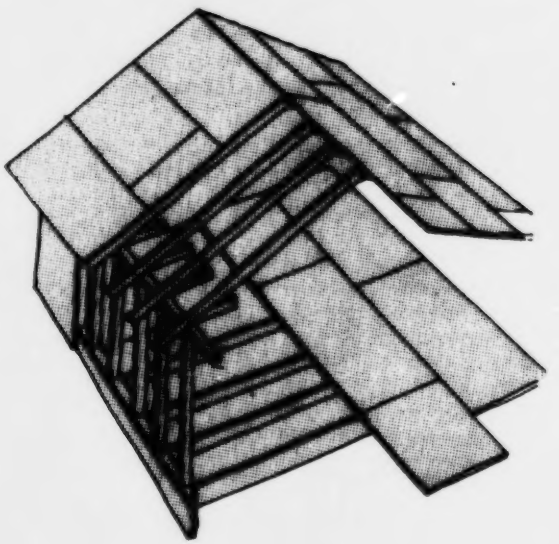
The Savings:

- The 1986 Alberta Home Cost Comparison Study indicates conventional rough framing for a 100 square meter, single detached dwelling to be in the order of $7,390. This figure includes all material and labour costs associated with the framing portion of the work.
- The OVE version of this design uses approximately $5,555 worth of rough framing materials and labour, or 25% less of the current material and labour inputs.

HISTORY & TRADE EXPERIENCE

Market Area/ Application:

- The 25% savings noted above represent one of the most notable OVE savings and one that is sure to appeal in the market place.



Major OVE Framing Components - all spacings at 24" o.c.

HISTORY & TRADE EXPERIENCE

Market Area/
Application:

- Walls framed at 600mm (24") on centre have fewer studs and thus more insulation, so average RSI values can be increased and energy costs lowered with the new framing system.
- The 600mm (24") OVE spacing and alignment of framing members is acceptable and applicable to single family homes and multi-family unit buildings, depending on number of storeys, loads and code limitations.

Trade
Comments:

- Cost-effective panel and frame floor, wall and roof systems save material and labour costs for the structural envelope.
- The development of the floor plan is one of the major design requirements in OVE planning. Interior layout is not influenced by the OVE concept. The use of clear-span, engineered roof trusses permits maximum freedom in arranging interior non-loadbearing partitions.
- The engineered 600mm (24") spacing system is a way to build rigid, substantial construction for lower cost using standard framing materials currently available in the Alberta marketplace.
- Less labour is required because there are fewer pieces to order, inventory, handle and install. Job procedures are also simplified.

Code
Reference: ABC SUBSECTIONS 9.23.1. - 9.23.18. Amendments required to ABC 1985: ____ Yes __X__ No

OVE TECHNIQUE: 2.4.2 OVE FLOOR FRAMING

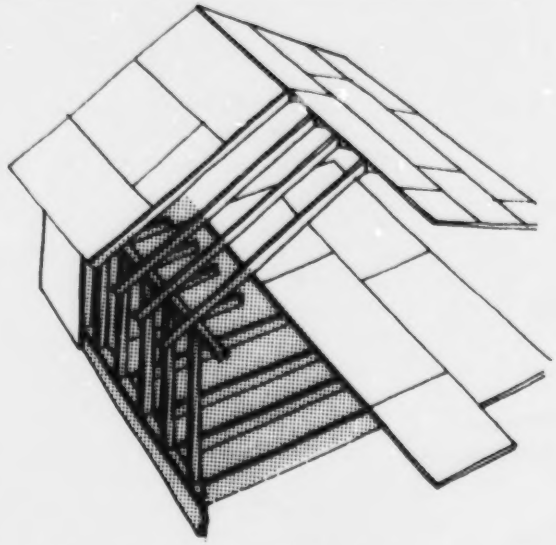
DESCRIPTION & ECONOMICS OF ADOPTION

The New Technique:

- Floor joists at the 600mm (24") on centre.
- Single headers are generally adequate for openings up to 1200mm in width.

What It Replaces:

- Conventional framing of floor joists at 400mm (16") on centre.
- In conventional framing, openings interupt more joists than with wider spaced OVE framing members, thus resulting in the need for double headers to span larger distances.



OVE Floor Joist Spacing at 24" o.c.

The Savings:

- Preliminary estimates indicate conventional floor joist framing for a 100 M^2, single detached dwelling to be about 1,525 FBM. The OVE version of this house, utilizing all applicable OVE floor framing concepts, would require only 901 FBM for the same floor area. This represents a cost savings of approximately 40% in materials or $313 on an average 100 M^2 house.

HISTORY & TRADE EXPERIENCE

Market Area/ Application:

- Engineering and design tests undertaken by the American Plywood Association have shown increased floor joist spacings will not be less rigid than conventional systems when installed correctly.
- Plan for straight run stairs because they disrupt as few floor joists as possible.

CURRENT IMPEDIMENTS/INCENTIVES TO USAGE

General:

- The implementation of OVE framing practices in Alberta would require an initial learning and transition phase where builders become familiar with the various OVE floor framing techniques and methods. After this, OVE construction practice should become more well known to the trades involved.
- The use of floor sheathing products, glued and nailed to the joists, greatly increases the overall performance and market acceptance of OVE floor framing systems.
- Attic or crawl space access doors should be located in a closet, hallway, or other appropriate areas. A 600mm spacing of members provides ample access to attics and crawl spaces; consequently, the framing of openings can often be reduced and double joists eliminated.

Trade Comments:

- Subfloor thickness must be increased slightly to work properly with wider 600mm (24") joist spacing.
- Some initial concern was expressed over rigidity of finished floor system, but builders seem willing to try system and then assess overall performance and buyer acceptance.
- A similar sized floor joist may sometimes be utilized with 600mm (24") floor spacings as is used for 400mm (16") spacings, depending on material, loading and method of attachment of the subflooring. For example, the ABC allows 38mm x 184mm (2"x 8") No. 2 SPF floor joists, in a living quarter application, to be spaced at 600mm (24") o.c., and to span 2.85 m (9'- 4"). By comparison, the code allows 38mm x 184mm (2"x 8") No. 2 SPF floor joists, in the same application, spaced at 400mm o.c. (16"), to span 3.49 m (11'- 5"). By simply increasing the depth of the joists to 38mm x 235mm (2"x 10"), spaced at 600mm (24") o.c., the span can be increased to 3.64 m (12'- 0"). This change in joist depth alone results in a material savings of 17% or almost $100.00 for an average sized house. When combined with other OVE floor framing principals this saving can be increased to 40%.
- By incorporating many of the individual OVE floor framing techniques, the average builder should be able to realize significant cost savings in both materials and labour involved with floor layout and framing construction time.

Code Reference: ABC SUBSECTION 9.23.9. & Table A-2 Amendments required to ABC 1985: ____ Yes __X__ No

OVE TECHNIQUE: 2.4.3 OVE WALL FRAMING

DESCRIPTION & ECONOMICS OF ADOPTION

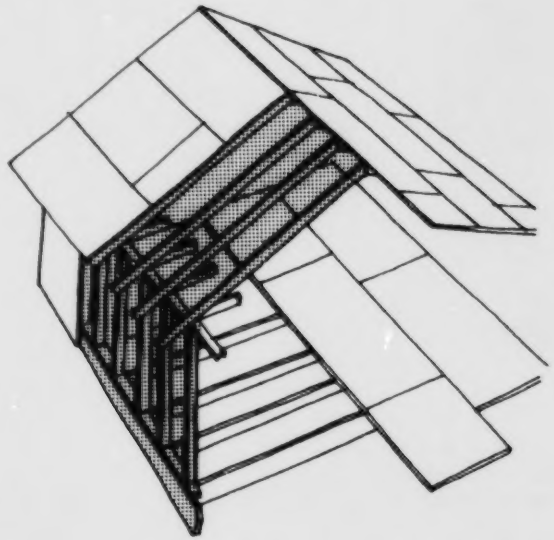
The New Technique:
- Space all studs, joists and rafters at 600mm (24") on centre consistently throughout the house structure.

What It Replaces:
- Conventional framing at 400mm (16") on centre.

The Savings:
- Conventional wall framing required for the 100 square meter ACCH house is 1,500 FBM of lumber. OVE wall framing techniques would require approximately 800 FBM of lumber or slightly over 50% of the material presently used in non-OVE wall construction. This would result in a cost saving of about $350 per house.

HISTORY & TRADE EXPERIENCE

Market Area/ Application:
- The average homeowner would not be able to distinguish the difference in appearance or performance between conventional wall stud spacings and OVE construction.
- Greater insulation coverage and efficiency is achieved with wider OVE stud spacings and simplified corner framing techniques.



OVE Wall Stud Spacing at 24" o.c.

OVE TECHNIQUE: 2.4.3 OVE WALL FRAMING

CURRENT IMPEDIMENTS/INCENTIVES TO USAGE

General:

- Conventional wood-framed walls are essentially a very efficient type of construction, but the full potential of the conventional 38 x 140mm framing is not often realized because of material waste.
- OVE spacing of wall studs must correspond with the floor joist and roof truss spacings to work most efficiently and to result in the greatest cost savings to builders and homeowners.
- Alberta building codes allow the extensive use of 600mm stud spacings for the majority of single and two storey housing applications. The use of standard thickness 12.7mm (1/2") drywall is acceptable by the code when the wider stud spacings are used. The use of slightly heavier wall sheathing is required when utilizing the 600mm (24") stud spacing.
- Ideally the openings in exterior walls using OVE construction should be placed on module, to ensure minimal waste of framing materials used for cripples and jacks used in conventional construction.

Trade Comments:

- Builders report that current strong market competition encourages housing consumers to compare detailed specifications. The concern is that if not all builders are using the wider OVE framing spacings, the buyer will choose the house with the 400mm (16") stud spacing perceiving it to be more strongly built.

Code Reference: ABC SUBSECTION 9.23.10. Amendments required to ABC 1985: ____ Yes __X__ No

OVE TECHNIQUE: 2.4.4 OPTIMUM JOIST LENGTH AND BEAM LOCATION

DESCRIPTION & ECONOMICS OF ADOPTION

The New Technique:

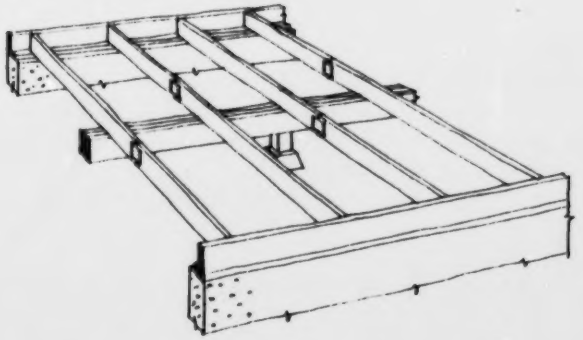
- Use an off-centre (cantilever) splice to maximize the use of even length floor joists.
- Locate the centre beam as near as possible to centre of the structure. If an offset is required, do so on an even foot mark such as 12' and 14' rather than at 11' and 13'.

What It Replaces:

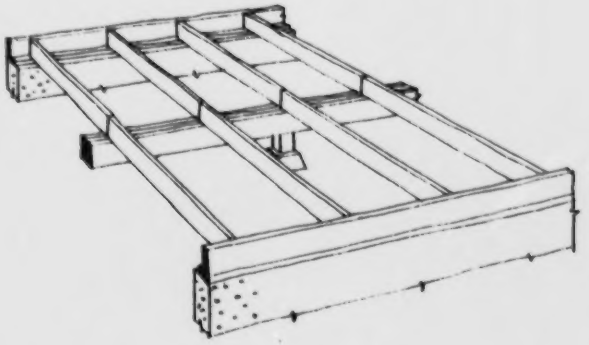
- Spans of uneven or cut joist lengths that result in wasted materials.

The Savings:

- Maximum benefits are achieved by having joist lengths that are of even length; in this case the beam line can be off-set slightly to allow joists of standard lengths to be used.
- For a given floor area, savings should reflected in reduced material costs and less wastage.



Off-centre Cantilever Splice (alternating)



Even Joist Length Span with Centre Beam

HISTORY & TRADE EXPERIENCE

Market Area/ Application:

- There would appear to be little market resistance in Alberta to the concept of adjusting plan size slightly to allow for economical use of even lengths of material for joist spans.

OVE TECHNIQUE: 2.4.4 OPTIMUM JOIST LENGTH AND BEAM LOCATION

CURRENT IMPEDIMENTS/INCENTIVES TO USAGE

General:
- The decision to adjust the floor plan to suit material lengths must be made in conjunction with the overall house design, layout and dimensions of the floor plan.

Trade Comments:
- May affect planning in two-storey applications; should only be used if joists and spacings are not changed.
- Less material wastage if even length framing members are used; no effect to trade practice.
- Length of joist trimmed may be left to increase size of house, at a low unit cost.

Code Reference: ABC SUBSECTION 9.23.4. Amendments required to ABC 1985: ____ Yes __X__ No

OVE TECHNIQUE: 2.4.5 CANTILEVERED FLOOR AREAS

DESCRIPTION & ECONOMICS OF ADOPTION

The New Technique:

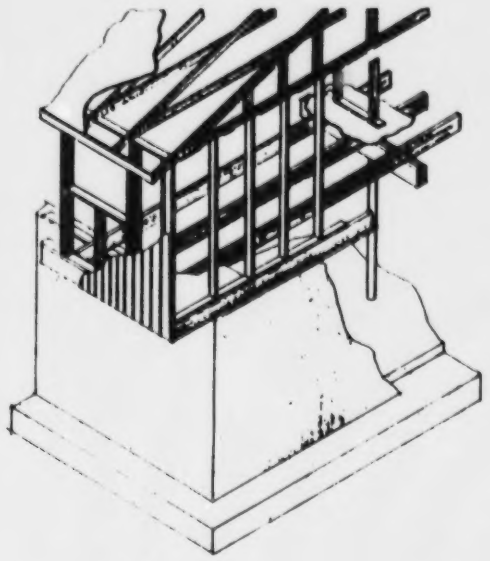
- Cantilevered floor areas over foundations and main floors in one-storey and two storey construction allow design variations and increased floor areas without complicating the foundations.

What It Replaces:

- Until recently, conventional Alberta practice was to support bay windows and extended floor areas with a full depth concrete foundation wall.

Savings:

- Floor cantilevers allow simpler, more economical foundation shapes. By using a cantilever floor area in place of one projected concrete foundation wall at a typical bay window installation, it is estimated that a cost-saving of approximately $275 could be achieved. This takes into account the deletion of a portion of the concrete wall and the inclusion of additional soffit insulation and sealing required by the cantilevered floor.



Cantilever Floor Area

OVE TECHNIQUE: 2.4.5 CANTILEVERED FLOOR AREAS

HISTORY & TRADE EXPERIENCE

Market Area/
Application: - Many current house designs in Alberta take advantage of the cantilever approach; bay windows and other projections are now commonly included as sales marketing tools.

CURRENT IMPEDIMENTS/INCENTIVES TO USAGE

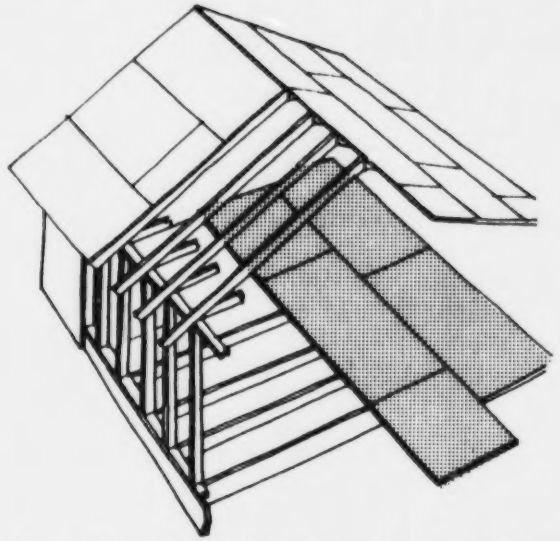
General: - Depending on joist size, the code allows floor cantilevers up to 600mm (24") measured from the face of the supporting structure. Cantilevers can not support floor loads from other storeys unless calculations are provided to show that the allowable design stresses of the cantilevered joists are not exceeded.

Trade
Comments: - The use of floor cantilevers must include proper installation and fit of the interior vapour barrier and insulation at critical junctures of floors and walls.

Code
Reference: ABC SUBSECTION 9.23.9.16. Amendments required to ABC 1985: ____ Yes __X__ No

OVE TECHNIQUE: 2.4.6 SINGLE LAYER FLOOR SHEATHING

DESCRIPTION & ECONOMICS OF ADOPTION



Single Layer T&G Flooring (supports at 24")

The New Techniques:

- Tongue-and-groove floor sheathing used in conjunction with a consistent and efficient 600mm (24") framing module should result in little scrap.
- Where carpet and/or resilient flooring are used throughout, one layer of tongue-and-groove plywood, waferboard, particleboard, or strand board can be often installed without the use of a separate layer of underlayment material.
- Wood bridging can be deleted where the subfloor is properly glued to floor joists with proper adhesive.

What It Replaces:

- Use of double floor construction system with subfloor and separate underlayment material such as plywood, hardboard, or particleboard.
- Solid blocking below all panel-type (non-tongue-and-groove) floors.
- Tongue and groove systems in plywood, chipboard and parallel strand lumber are gradually replacing separate subfloor and underlay type installations in the province.

The Savings:

- Single layer tongue-and-groove sheathing permits direct application of finish floor materials such as carpet, tile, and most sheet goods, without the additional labour and material cost of underlayment materials. Taking into account the slight extra thickness of the tongue-and-groove sheathing required, the total deletion of underlayment material for an average sized house can result in a cost saving of approximately $280. Where single layer flooring is already specified, the deletion of underlayment in areas where sheet vinyl flooring is specified could result in a cost-saving of approximately $125.00.
- Where solid blocking is deleted under conventional floor sheathing products, the material and labour cost savings would be approximately $65.00.

HISTORY & TRADE EXPERIENCE

Market Area/
Application:
- Double floor systems (sheathing and underlay) or solid wood blocking below panel type products are still being used in some residential markets in the province.

CURRENT IMPEDIMENTS/INCENTIVES TO USAGE

General:
- Underlay material is not required where panel type subflooring has the edges supported by means of blocking or tongue-and-groove joints.
- It is recommended that single layer flooring systems be adequately glued to the joists to take advantage of composite action; this will increase the stiffness and/or allowable span of the entire floor system.
- Tongue-and-groove floor systems with glue to the grooved joints offer superior rigidity and have fewer call-backs because of movement or squeaks.

Trade
Comments:
- The framer can complete the flooring installation in one operation.
- Glue application of flooring can be difficult in cold weather; care must be taken to avoid freezing of the products.
- Some framers recommend screwing down the subfloor, rather than gluing and nailing.
- When glue-nailing is used on a floor system it is not necessary to provide joist restraint or bridging (ABC: 9.23.9.8.).
- More accurate materials take-offs and preplanning for module spacing would allow trades to save on materials and site labour costs.

Code
Reference: ABC SUBSECTION 9.23.14 and 9.31.2 Amendments required to ABC 1985: ____ Yes __X__ No

Note: No allowance is currently available in the code for increased spans in conjunction with glue-nailing of subfloors. Glue-nailing is still recommended for its benefits of stiffness and performance and because it allows the deletion of bridging or other joist restraint.

OVE TECHNIQUE: 2.4.7 ELIMINATION OF JOIST BRIDGING

DESCRIPTION & ECONOMICS OF ADOPTION

The New Technique:

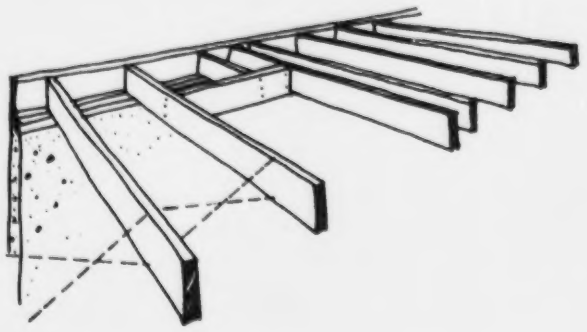
- Cross bridging or solid blocking between joists is not required when glue-nailed panel type flooring systems are used.

What It Replaces:

- The building code requires bridging on most or all joist spans over 2 meters in length.

The Savings:

- Estimates to eliminate conventional bridging for a 100 square meter, single detached dwelling to be approximately $85. This figure includes all material and labour costs associated with the work. By utilizing glu-nailing, this component of the framing cost can be eliminated.



Bridging eliminated where glue-nailed panel type flooring is used

HISTORY & TRADE EXPERIENCE

Market Area/ Application:

- Framers are still providing bridging in most cases due to a lack of information and code knowledge.
- Glu-nailing is not used by all framers.

CURRENT IMPEDIMENTS/INCENTIVES TO USAGE

General:

- A glue-nailed floor system will provide better performance than conventional floor sheathing simply nailed to the floor framing.
- Bridging does not contribute appreciably to the performance of the floor.
- Bridging can detract from floor performance by increasing the effect of vibrations from walking on the floor.
- In the past, the use of 'green' lumber may have influenced some builders to incorporate bridging in the majority of installations. The current moisture content for framing of 19% maximum assures that wood shrinkage is kept to a minimum.

Trade Comments:

- There are potential cold weather problems associated with installation of glue-nailed subfloor systems.
- The use of surface dry lumber for framing members retards nail pops and warping.

Code Reference: ABC SUBSECTION 9.23.9.5. thru .8. Amendments required to ABC 1985: _____ Yes __X__ No

OVE TECHNIQUE: 2.4.8 SUPPORTING NON-LOADBEARING PARTITIONS

DESCRIPTION & ECONOMICS OF ADOPTION

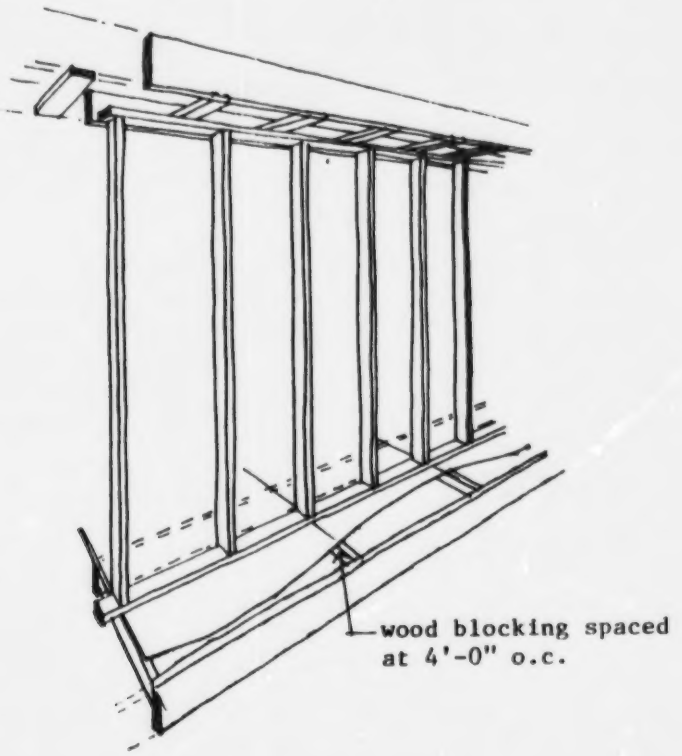
The New Technique: - Where non-loadbearing partitions run parallel with the floor joists, it is not necessary to provide double floor joists under all walls.

What It Replaces: - Conventional practice has been to provide double joists under all partition walls.

The Savings: - Labour and material estimates indicate that the elimination of conventional doubled joists under all non-loadbearing partitions for a 100 square meter house would result in a cost savings of approximately $65.

HISTORY & TRADE EXPERIENCE

Market Area/ Application: - The framing trade continues to provide double floor joists under non-loadbearing partition walls, even though alternative support could be provided.



Support of Non-loadbearing Partition walls with blocking

OVE TECHNIQUE: 2.4.8 SUPPORTING NON-LOADBEARING PARTITIONS (cont.)

CURRENT IMPEDIMENTS/INCENTIVES TO USAGE

General:

- ABC 1985 does not allow the deletion of support under non-loadbearing partition walls, but will allow the use of a blocking instead of solid joists. Pre-cut 38mm x 89mm (2"x4") blocking spaced at 1.2 m (4'-0") is considered more economical to supply and install than solid joists and meets the requirements of the code.

Trade Comments:

- It is not necessary to align the studs of non-loadbearing walls in OVE construction with floor and roof framing.
- In two storey construction the deletion of floor joists under partitions may be a concern where load transfer may result from slight shrinkage of the floor above. Allow an open space between second floor joists and partition walls below to accomodate for such shrinkage or movement.

Code Reference: ABC SUBSECTION 9.23.9.12. Amendments required to ABC 1985: ____ Yes _X_ No

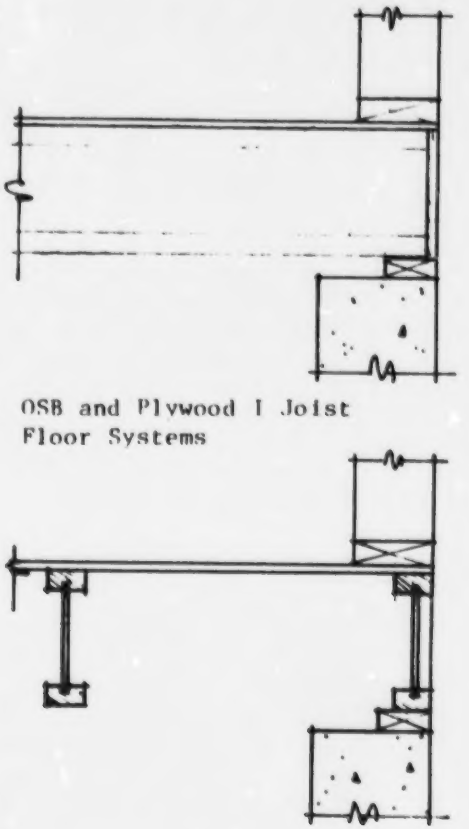
OVE TECHNIQUE: 2.4.9 OSB AND PLYWOOD I JOISTS

DESCRIPTION & ECONOMICS OF ADOPTION

The New Technique: - Where longer spans are required by design and layout, the use of oriented strand board (OSB) and plywood I joists can prove more economical than conventional wood dimension lumber.

What It Replaces: - Conventional sawn wood joists.

The Savings: - Longer span designs will usually be more economical with the use of OSB and plywood I joists. It is reported the in-place cost for I joists is from 5% to 15% less than that of solid joists and rafters, for a given long-span installation. This could result in a cost saving of between $50 and $115 for the floor of an average 100 sq. meter house.



OSB and Plywood I Joist Floor Systems

HISTORY & TRADE EXPERIENCE

Market Area/ Application: - Larger custom-designed houses having longer spans may benefit most, since flexibility in planning and layout are the key benefits.

CURRENT IMPEDIMENTS/INCENTIVES TO USAGE

General:

- The product is usually of high quality, since it is manufactured in a climate-controlled plant.
- OSB and plywood I joists have a high load capacity and excellent weight-to-strength ratio and outspan dimension lumber. The result is a strong member which is stiffer than conventional dimension joists of the same depth.

Trade Comments:

- Joists are light and can be easily carried by one man.
- Standard carpenter's tools may be used for installation.
- Dimensionally stable, they will not twist or warp.
- Can accommodate heating ducts cut through the web members.
- A careful cost comparison must be worked out to determine if the product is price effective in a given application.

Code Reference: ABC SUBSECTION 9.24.3. Amendments required to ABC 1985: _____ Yes __X__ No

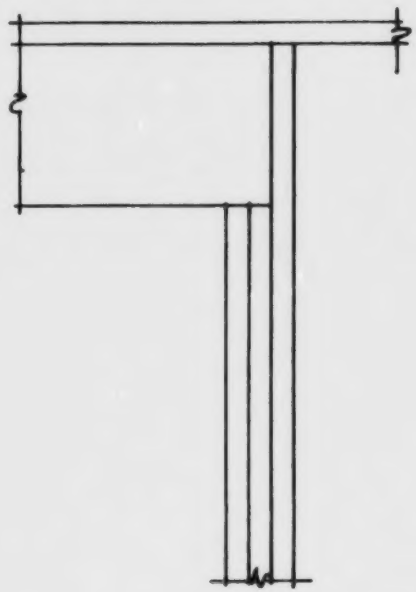
OVE TECHNIQUE: 2.4.10 LAMINATED PLY-BEAMS

DESCRIPTION & ECONOMICS OF ADOPTION

The New Technique: - Where greater load capacity and longer spans are required by design and layout, the use of laminated ply-beams may prove more economical than conventional wood built-up beams.

What It Replaces: - Solid sawn headers, conventional 38mm (2") wood built-up beams, steel beams, and glu-lam beams. In-place costs should be reviewed in each circumstance.

The Savings: - The material and labour cost saving for eliminating conventional built-up wood beams and using laminated ply-beams instead is approximately $45 for an average sized house.



Ply-Beam application at a door or window location (load-bearing)

HISTORY & TRADE EXPERIENCE

Market Area/ Application: - Heavier load and longer span designs will usually be more economical with the use of ply-beams.

CURRENT IMPEDIMENTS/INCENTIVES TO USAGE

General: - The product is usually of high quality, since it is manufactured in a climate-controlled plant.

CURRENT IMPEDIMENTS/INCENTIVES TO USAGE

General:
- Plywood I beams have a high load capacity and excellent weight-to-strength ratio; they outspan dimension lumber and are stiffer than conventional built-up beams and joists of the same depth.

Trade Comments:
- Ply-beams are light weight and can be easily carried by one man.
- Standard carpenter's tools may be used for installation.
- Dimensionally stable, they will not twist or warp.

Code Reference: ABC SUBSECTION 9.24.3. Amendments required to ABC 1985: _____ Yes __X__ No

DESCRIPTION & ECONOMICS OF ADOPTION

The New Technique:

- Use metal drywall clips at corners, partition wall intersections, and ceilings.

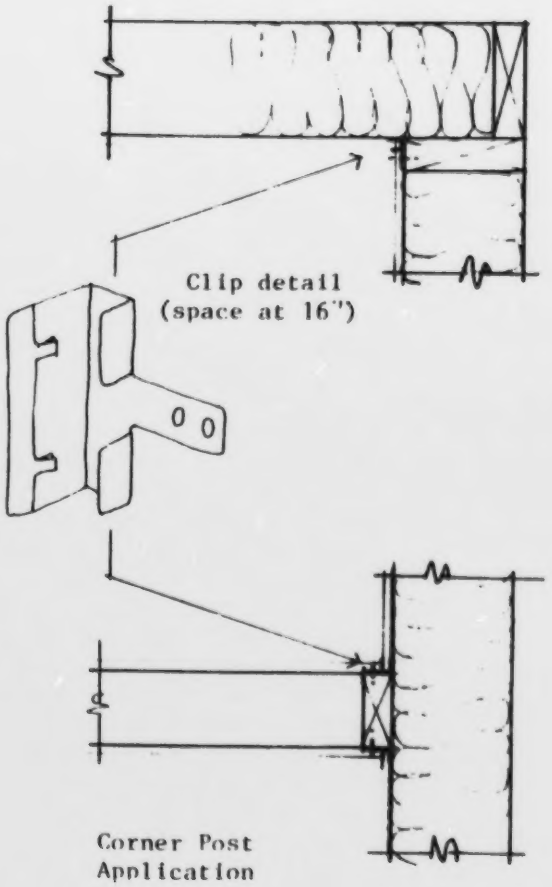
What It Replaces:

- Conventional construction practice generally employs three stud corner posts, three stud partition posts and continuous wood blocking at ceilings.

The Savings:

- The total cost of labour and materials for drywall clips amount to approximately $90.00. The use of metal clips could result in a total cost saving of approximately $200 for a 100 sq. meter house. Estimates indicate that conventional wood stud back-up material and labour required behind drywall for the same sized house to be about $290.
- Reports of lumber savings of up to 10% have been reported by builders who use the drywall clip system.
- Energy costs can be reduced by eliminating uninsulated or poorly insulated stud boxes at corners and partitions; the use of clips eliminates the cutting of blanket insulation at corners. Energy consumption reductions of 2% per year have been achieved.

Corner Post Application



OVE TECHNIQUE: 2.4.11 DRYWALL CLIPS (cont.)

HISTORY & TRADE EXPERIENCE

Market Area/
Application: - Saving of wood studs at all typical intersections and corners amounts to significant materal and labour cost saving.

CURRENT IMPEDIMENTS/INCENTIVES TO USAGE

General:
- Better insulation coverage and continuous vapour barrier installation is possible between studs when extra corner and partition studs are eliminated.
- The maximum load on the corner stud is, at most, one half or less than the load on a regular stud: two stud corners are adequate structurally.
- The corner is formed from the end studs in each of the two wall panels which meet at the corner; they are then simply nailed together in a conventional fashion.
- The use of metal drywall clips can save time and lumber and make allowance for warped or inaccurate framing.

Trade
Comments:
- The drywall trade installs clips at the time of boarding, being careful not to damage the vapour barrier (not a concern with the Air-tight Drywall Approach). Added labour required by drywall trade to install clips is considered minimal. Many types are simply pushed over the ends of the board and screwed or nailed in place, as is usual when boarding. Clips permit adjustment of framing inaccuracy up to a width of a stud.
- One trade is responsible for the backing provisions and the supply and installation of its own materials, rather than relying on another trade to locate blocking properly.
- Framers must currently make allowances for proper location of conventional wood cleats or backing; allowances are no longer required with metal clips. They eliminate delays in roof truss erection while backup framing is installed.
- Conventional practice often does not allow proper, or indeed any insulation to be installed in the corner and partition post locations, since framers have traditionally been required to do this job. When installed by framers, this insulation often gets wet during the course of construction and does not ultimately function as intended.

Code
Reference: ABC SUBSECTION 9.23.10.4. & 9.30.8. Amendments required to ABC 1985: ____ Yes __X__ No

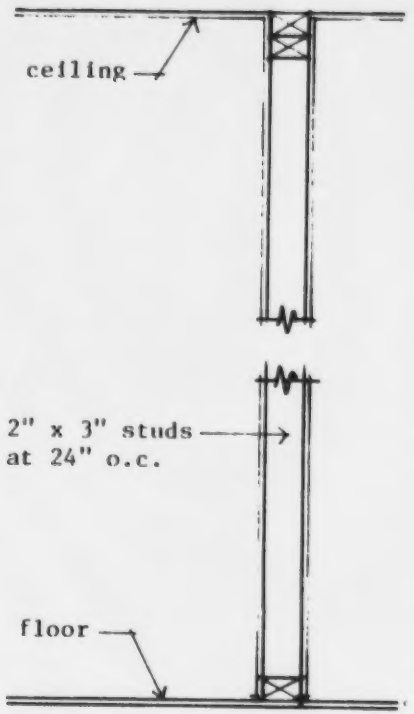
OVE TECHNIQUE: 2.4.12 PARTITION FRAMING - NON-LOADBEARING

DESCRIPTION & ECONOMICS OF ADOPTION

The New Technique: - Use 38mm x 64mm (2"x 3") wood studs spaced at 600mm (24") on centre in non-loadbearing interior partitions.

What It Replaces: - Standard 38mm x 89mm (2"x 4") studs spaced at 400mm (16") on centre for interior non-loadbearing partitions.

The Savings: - The use of alternate interior wall framing could result in a total cost saving of approximately $235 for a 100 sq. meter house; as well, useable floor space is estimated to increase by 1.5 sq. meters (16 sq. ft.). Estimates indicate that conventional interior partitioning for the same sized house to be about $550. These figures include all material and labour costs associated with the work.



Interior Non-loadbearing Partition

HISTORY & TRADE EXPERIENCE

Market Area/ Application: - Occupants of an OVE designed home with slightly narrower interior partition framing are probably unaware of any structural difference.

CURRENT IMPEDIMENTS/INCENTIVES TO USAGE

General:

- The relative size of non-loadbearing stud walls can be reduced in size as compared to loadbearing walls.
- The use of smaller stud construction meets the performance requirement of non-loadbearing interior partitions and has been well accepted wherever used.

Trade Comments:

- Because the studs are non-loadbearing, it is not necessary to coordinate their positions with OVE structural members in the floor or roof. They may be located as desired and the studs need not bear directly over other framing members.
- Although a 19mm x plate, top and bottom of the stud wall is considered to be adequate for basic strength, it is recommended that 38mm x material be used for added wall rigidity and resistance to warpage, particularly when studs are drilled for wiring, etc.
- Conventional door jamb widths do not lend themselves to the narrower width of 64mm (3") walls. Alternative trim details must be incorporated or jambs can be easily cut on site to allow the use of currently manufactured door jambs. The width of jambs will be adjusted by manufacturers if the market need is confirmed over time, the same way window jamb sizes have changed to accomodate more heavily insulated and wider exterior walls.
- The depth of electrical boxes and outlets will clear narrower wall thickness.

Code Reference: ABC SUBSECTION 9.23.10. Amendments required to ABC 1985: _____ Yes __X__ No

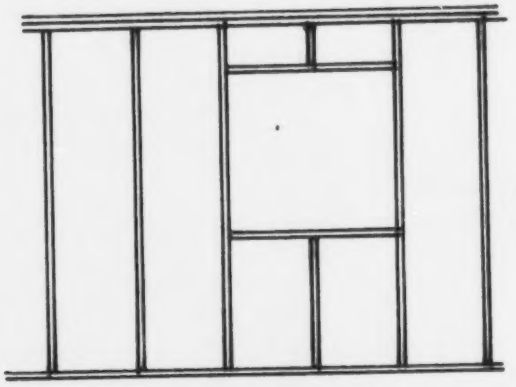
OVE TECHNIQUE: 2.4.13 FRAMING COORDINATION OF EXTERIOR OPENINGS

DESCRIPTION & ECONOMICS OF ADOPTION

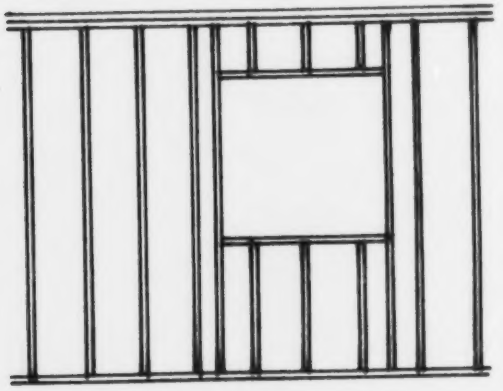
The New Technique: - Coordinate the location of door and window openings in the exterior wall with the modular stud spacing on at least one side.

What It Replaces: - Solid dimension lumber headers over all door and window openings and cripples and jack studs, regardless of whether the walls are loadbearing.

The Savings: - The coordinated placement of framing at exterior openings could result in a total cost saving of approximately $85 for a 100 sq. meter house.



Coordinated OVE window Opening
(studs at 24" o.c.)



Non-coordinated Window Opening
(studs at 16" o.c.)

HISTORY & TRADE EXPERIENCE

Market Area/ Application: - Where windows are located in non-loadbearing exterior walls, there is no need for costly headers, jack studs, and cripples. Installation of windows is also faster and more efficient.

OVE TECHNIQUE: 2.4.13 FRAMING COORDINATION OF EXTERIOR OPENINGS (cont.)

CURRENT IMPEDIMENTS/INCENTIVES TO USAGE

General:

- The use of nominal 560mm (22") wide modular window units can be coordinated with stud spacings. Height of window can be varied to provide different window opening areas.
- Openings of 1200mm (4'-0") wide can also be coordinated with wall panel sizes used on the exterior of the structure.

Trade Comments:

- It is best to locate large openings in the gable ends of a building to eliminate the need for structural headers.
- Larger number of windows in sequence can be installed in between regular stud spacings for desired design effect.
- The use of narrower windows may present a design and market challenge.
- Significant savings of material and labour result compared with conventional trade practice.

Code Reference: ABC SUBSECTION 9.23.12. Amendments required to ABC 1985: ____ Yes __X__ No

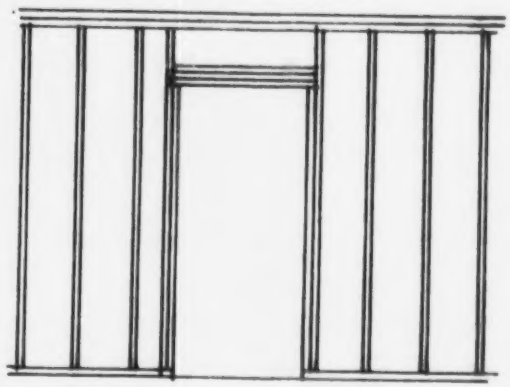
OVE TECHNIQUE: 2.4.14 FRAMING OF INTERIOR DOOR OPENINGS

DESCRIPTION & ECONOMICS OF ADOPTION

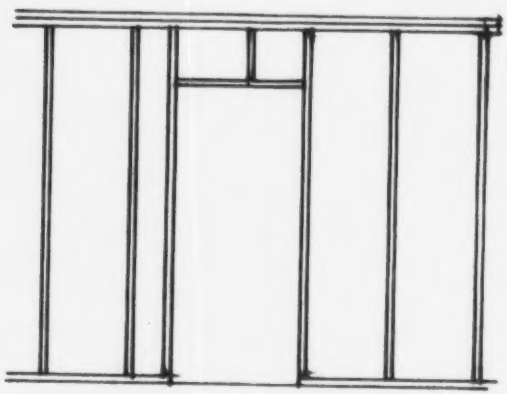
The New Technique: - Single framing can be utilized for non-loadbearing partitions for passage doors, closets, and other openings; there is no need for cripples.

What It Replaces: - Double framed interior openings with additional cripples and headers which are often not necessary.

The Savings: - A simplified framing detail that minimizes corners around door and closet openings can save about $6 per opening on framing and finishing costs. For an average sized house of 100 sq. meters the total cost saving would be approximately $54.



Double Framed Opening
(studs at 16" o.c.)



Single Framing (non-loadbearing)
(studs at 24" o.c.)

HISTORY & TRADE EXPERIENCE

Market Area/ Application: - Internal deletions of material where not required structurally will not have any negative impact on the market performance.

CURRENT IMPEDIMENTS/INCENTIVES TO USAGE

General:

- No structural headers are required over over non-loadbearing partitions. All that is required is one stud on the flat.
- Where folding or bifold closet doors are used, the door opening should be framed or "stubbed" at only one end to save framing material.

Trade Comments:

- Framing may be further simplified by using ceiling-height closet doors.

Code Reference: ABC SUBSECTION 9.23.12. Amendments required to ABC 1985: _____ Yes __X__ No

OVE TECHNIQUE: 2.4.15 ACCURATE HEADER SELECTION

DESCRIPTION & ECONOMICS OF ADOPTION

The New Technique:

- Select the proper size header for the loading conditions in each house and each opening. Use metal hangers for header support, rather than cripples.

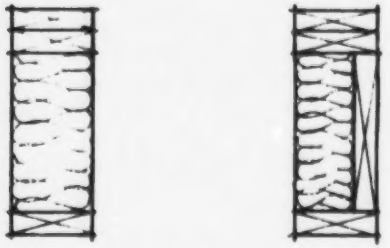
What It Replaces:

- Headers are sized for the largest opening or load in the structure, then all openings are constructed of the same member size, regardless of specific loading or width.

The Savings:

- Material and labour cost savings of approximately $75 would be achieved by decreasing header sizes where allowed by loading conditions, the use of metal hangers, and the elimination of headers at openings in walls where no loads are present.

Header designed for maximum load (uninsulated)



OVE Headers designed for actual loading conditions (insulated)

HISTORY & TRADE EXPERIENCE

Market Area/ Application:

- The elimination of extra materials that have no bearing on structural rigidity, coupled with greater levels of insulation would be an attraction in the marketplace.
- The alignment of openings vertically in two storey OVE construction will minimize header loads.

OVE TECHNIQUE: 2.4.15 ACCURATE HEADER SELECTION (cont.)

CURRENT IMPEDIMENTS/INCENTIVES TO USAGE

General:

- Where load conditions permit, a single 38mm x 184mm (2"x 8") header may be used in a stud wall with the addition of 38mm x blocking along the bottom edge, to serve as a nailer for drywall.
- Minor changes to the locations and positions of openings in two storey homes do not pose a problem for OVE construction.
- Where a window or door opening occurs directly beneath an opening in a two storey house, the lower header may be carrying floor loads only. It is therefore to the builder's advantage to align openings vertically.

Trade Comments:

- Headers are often over-designed and do not allow the installation of adequate insulation between the members. In most cases there is no room left for insulation.
- They are often found in non-loadbearing and end walls of houses where they are not required to carry loads.
- Higher levels of insulation are possible where headers are properly engineered and installed to allow for better insulation coverage.
- Metal hangers allow for fast and accurate installation of headers where standard cripples are used in conventional construction.

Code Reference: ABC SUBSECTION 9.23.12. Amendments required to ABC 1985: ____ Yes __X__ No

OVE TECHNIQUE: 2.5.1 EXTERIOR FINISH AND TRIM

DESCRIPTION & ECONOMICS OF ADOPTION

The New Technique:

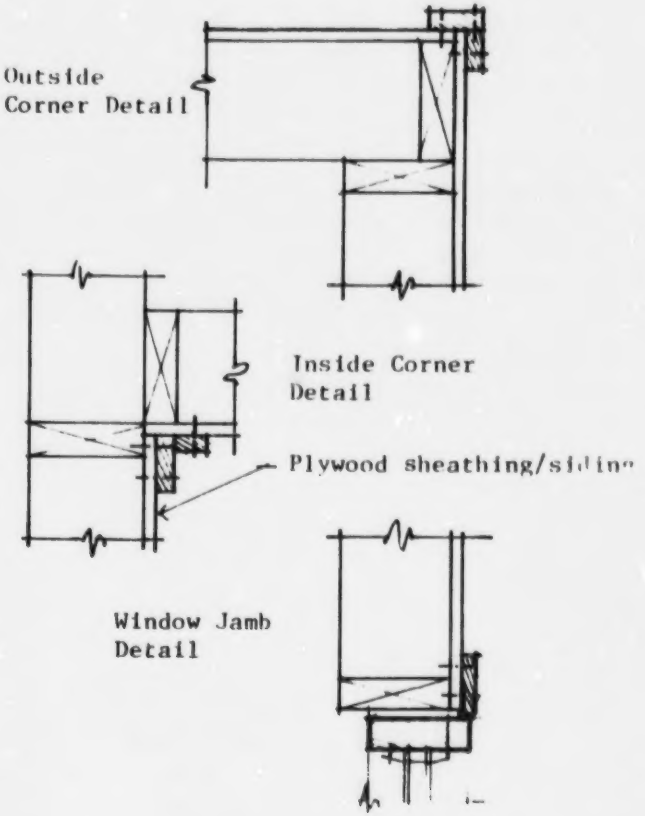
- Use less expensive lumber on trim when solid pigmented stains are used for exterior finishing.
- When more elaborate trim elements are required by the exterior design, investigate the use of moulded plastic elements or prefinished aluminum.

What It Replaces:

- Expensive wood mouldings and millwork which may require additional site labour to fit and finish.

The Savings:

- Where less expensive stained or prefinished trims are used, it may be possible to save up to $140.00.



HISTORY & TRADE EXPERIENCE

Market Area/ Application:

- When used in conjunction with prefinished siding, door and window units, the use of prefinished trim will totally eliminate exterior painting as a separate operation.

CURRENT IMPEDIMENTS/INCENTIVES TO USAGE

General:
- The use of exterior trim can be minimized and prices kept down.
- Moulded plastic trims and profiles are available to replicate most elaborate wood elements.
- Accessories such as coloured caulk, and siding nails can minimize the need for more expensive trim and are widely available.

Trade Comments:
- Traditional site painting trade should be eliminated or the required time decreased when using OVE measures related to trim.
- Where prefinishing of exterior elements is performed by the builder, arrangements can be made to prefinish all other trim elements of the exterior package.

Code Reference: Amendments required to ABC 1985: _____ Yes __X__ No

OVE TECHNIQUE: 2.5.2 ROOF TRIM DETAILS

DESCRIPTION & ECONOMICS OF ADOPTION

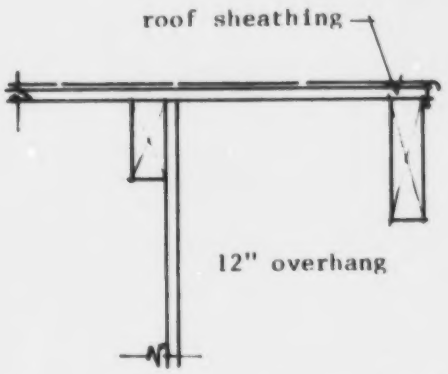
The New Technique:
- Eliminate or use less expensive lumber for rake and eaves trims when the natural characteristics of the wood are treated as an architectural feature.

What It Replaces:
- Traditional details often include a fascia, soffit, and required blocking, frieze, and various other moldings. Many of these details can be simplified or eliminated with no loss in function.

The Savings:
- Where it is possible to eliminate soffit boxing-in or prefinished aluminum material and substitute simple rake boards, it is possible to save up to $265.00.

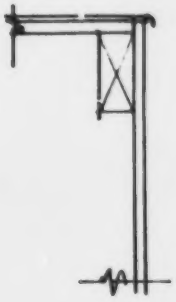
HISTORY & TRADE EXPERIENCE

Market Area/ Application:
- Market resistance may be a factor against total soffit finish deletion.
- Conventional practice includes site painting and finishing of traditional trims and other pieces of the exterior elements.



Open Soffit Detail with Rake Board

Simple Rake Board



Trim eliminated

CURRENT IMPEDIMENTS/INCENTIVES TO USAGE

General:

- A solid stain finish may be considered for rake and soffit trim; this type of finish is less sensitive to job conditions.
- Trim located at the rake edge of the roof is essentially nonfunctional; 19mm (3/4") thick trim pieces may be installed to conceal field tolerances by covering the rough edges of the gable and/or siding.
- Where attic venting can be accomplished with vents at the gable ends of the roof, the traditional soffit overhang may be entirely eliminated. Gutters should still be installed to avoid problems of water running down the wall.
- The amount of roof overhang depends on the truss design and the amount of summer shading desired. It may be possible to eliminate all underside soffit trim details.
- Fascia boards may be eliminated.
- Truss ends, where left exposed, can be finished before installation. This cuts down on costly field finishing.

Trade Comments:

- Fascia boards used across the truss ends help support roof edge and appear more finished.
- It is advantageous to prefinish roof trim items, off site to reduce field labour time and avoid paint lines and runs on the siding.

Code Reference: ABC SUBSECTION 9.28 Amendments required to ABC 1985: _____ Yes __X__ No

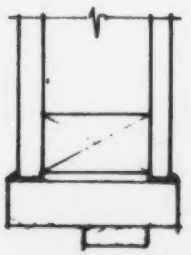
OVE TECHNIQUE: 2.5.3 REDUCE INTERIOR DOOR AND WINDOW TRIM

DESCRIPTION & ECONOMICS OF ADOPTION

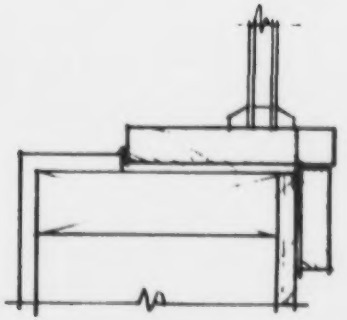
The New Technique:
- Return the drywall into the openings at the heads and jambs of windows and doors.
- Butt and caulk drywall into window frames and pre-hung doors.

What It Replaces:
- Full wood trims around the entire window or door perimeter opening, including jambs and heads.

The Savings:
- Drywall returns at doors and windows can result in net cost saving of approximately $138.00 per house.



Interior Pre-hung Door Detail



Exterior Window Detail

HISTORY & TRADE EXPERIENCE

Market Area/ Application:
- Drywall returns are now fairly common in the Alberta market place; curtains and blinds often conceal the window edges from view.

CURRENT IMPEDIMENTS/INCENTIVES TO USAGE

General:
- At wooden windows and doors the drywall may be inserted in the shim space between the window or door frame and the rough framing and caulked.

CURRENT IMPEDIMENTS/INCENTIVES TO USAGE

General:

- A painted wood stool or sill is usually advisable at windows, since higher insulation standards in Alberta homes may result in condensation forming on the inside faces of the windows. The sill should slope slightly toward the window frame to prevent moisture damage below the window. Without a wooden sill, moisture could run down the window face and cause damage to a drywall window sill.

Trade Comments:

- Drywall trade often covers corners and areas of wall adjacent to window or door openings.
- Smallest practical size of trims to be used should be no smaller than 12mm (1/2") x width required.

Code Reference: ABC SUBSECTION 9.30 Amendments required to ABC 1985: ____ Yes __X__ No

OVE TECHNIQUE: 2.5.4 CLOSET DOORS AND TRIMS

DESCRIPTION & ECONOMICS OF ADOPTION

The New Technique:
- Full height, prefinished closet doors.
- Elimination of stub walls.

What It Replaces:
- Made-to-measure type doors, with bulkheads, custom sized framing and site application of finishes.

The Savings:
- Full height closet doors, without dropped bulkheads and custom framing can result in net cost saving of approximately $72.00 per house.

Typical 48" closet opening with coordinated framing at 24" o.c. (OVE method)

Closet with stub walls, bulkhead and framing at 16" o.c. (Conventional method)

HISTORY & TRADE EXPERIENCE

Market Area/ Application:
- With the large number of types and sizes available, it should be possible to select a cost effective closet door unit.

CURRENT IMPEDIMENTS/INCENTIVES TO USAGE

General:
- Choose door units on the basis of trouble-free operation, rigidity, and finish.
- No trim is usually required around closet openings with most types of bifold, accordian, or sliding doors.

CURRENT IMPEDIMENTS/INCENTIVES TO USAGE

General:

- Shelf and hanger choices in OVE construction can range from painted particle board to vinyl-coated wire, to simply painted 19mm (3/4") x 300mm (12") dry lumber. In all cases the most cost effective choice will be governed by the total expenditure of labour and materials. Intermediate supports for each type of shelf/rod combination must be adequately sized for best performance.
- Ceiling height doors can permit installation of an extra shelf to increase closet capacity.
- Shelf ends are best supported by 19mm (3/4") x width required, dry lumber cleats to span between sidewall studs. Cleats may be precut in the shop.
- A standard 30mm diameter wood closet pole is the most economical means of providing hanger storage. Wire racks on brackets eliminate the need for a separate pole, but installed cost must be compared.

Trade Comments:

- Closet doors which suit larger openings without the need for wall stub-outs are preferred by finishing trades.
- All closet poles, shelves, brackets, etc. should be installed prior to interior painting.

Code Reference: ABC SUBSECTION 9.6 Amendments required to ABC 1985: ____ Yes __X__ No

DESCRIPTION & ECONOMICS OF ADOPTION

The New Technique:

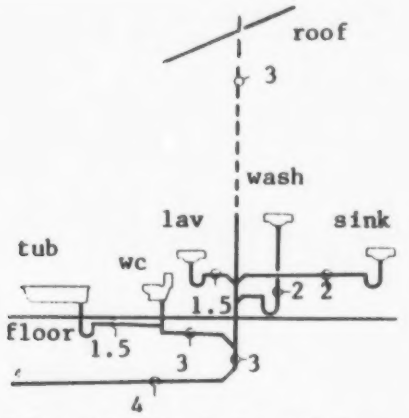
- Arrange all of the typical plumbing groupings such as baths, kitchen and laundry back to back on a common wall.
- Stack venting allows each fixture drain to be connected individually to the plumbing stack, eliminating the need for individual fixture vents.

What It Replaces:

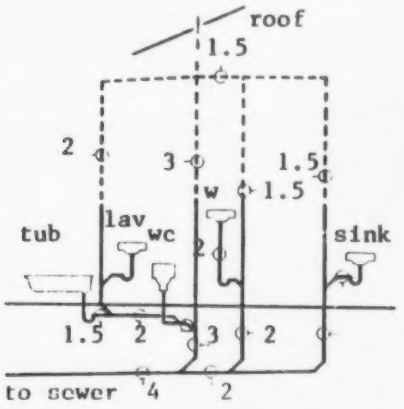
- Plumbing layouts that are disjointed, with long runs of piping and complicated venting.
- A number of plumbing drains connected together on a single line, requiring venting to be connected above each fixture to prevent the loss of trap seals.

The Savings:

- Using these techniques, it is possible to achieve savings from $200 to $260.00 on an average house by minimizing the amounts of drain, waste and vent (DWV) and water piping labour and materials otherwise used in remote fixturing arrangement.



Schematic-Stack Vented System



Schematic-Typical System

OVE TECHNIQUE: 2.6.1 CENTRALIZED PLUMBING (cont.)

HISTORY & TRADE EXPERIENCE

Market Area/
Application:
- Plumbing layouts appear to be installed as an afterthought in many home installations.
- Stack venting system is particularly suited to single bath/laundry/kitchen combinations clustered about a single stack.

CURRENT IMPEDIMENTS/INCENTIVES TO USAGE

General:
- Ground work rough-in is minimized with cluster or back-to-back plumbing layouts.
- All fixtures, if possible, should discharge into a common stack and vent system and are supplied by a common hot and cold water riser.
- The vent portion of the stack may be reduced according to reduced vent procedures to provide additonal savings.

Trade
Comments:
- Pre-planning of the complete plumbing/drainage system is required, and slight adjustments can then be made to satisfy the stack venting measures.
- Water heater should be located close to cluster plumbing location.

Code
Reference: ABC SUBSECTION 7.2 and SECTION 9.32 Amendments required to ABC 1985: _____ Yes __X__ No
The Plumbing and Drainage Act Regulations, Part 15, Venting System, Division 2.

OVE TECHNIQUE: 2.6.2 REDUCED DRAIN & VENT PIPE SIZING

DESCRIPTION & ECONOMICS OF ADOPTION

The New Technique: - Laboratory and field tests in the United States have shown that 75mm (3") drains and vents as small as 12mm (1/2") in diameter can perform satisfactorily in typical house installations, their primary function being to equalize atmospheric pressure in a DWV system in order to prevent trap seal loss.

What It Replaces: - Conventional sizing and design of drains and vent pipes, as prescribed by current codes, can handle at least twice the volume of wastes discharged by modern fixtures.

The Savings: - Labour and material changes associated with reduced drain and venting piping could result in savings of between $400.00 and to $700.00 for an average sized house.

HISTORY & TRADE EXPERIENCE

Market Area/ Application:
- Code changes would allow smaller pipe sizes to match conserving fixtures, and reduce venting requirements.
- Numerous technical and design bulletins on reduced venting are available from the U.S. National Bureau of Standards, Center for Building Technology. Results of field studies are also available from the NAHB Research Center.

CURRENT IMPEDIMENTS/INCENTIVES TO USAGE

General:
- Cost savings with reduced drain and vent systems vary by the quantity of larger size vent piping that can be replaced by smaller vents coupled with the added cost of reduced fittings.
- Vent stacks terminating through roof overhangs and side walls can also be considered.

Code Reference: The installation of reduced venting systems requires special permission by code authorities. Amendments required to ABC 1985: _X_ Yes ____ No

OVE TECHNIQUE: 2.6.3 FIBERGLASS BATH MODULES

DESCRIPTION & ECONOMICS OF ADOPTION

The New Technique: - Fiberglass-reinforced plastic tub and shower units with an integral wall surround provide a jointless, leakproof enclosure.

What It Replaces: - Ceramic tiles with grouted joints in the tub and shower areas.

The Savings: - The net cost saving to substitute a fiberglass enclosure in place of conventional grouted tiles would be in the order of $45.00.

HISTORY & TRADE EXPERIENCE

Market Area/ Application: - Fiberglass tubs and surrounds are now popular in the Alberta marketplace.

CURRENT IMPEDIMENTS/INCENTIVES TO USAGE

General:
- Care must be taken to caulk around the hole for the mixing valve.
- Leaks and callbacks associated with tile grouting are eliminated and any repairs to fiberglass can be easily completed on site, often without having to remove the tub or surround.

Code Reference: ABC SUBSECTION

Amendments required to ABC 1985: _____ Yes __X__ No

OVE TECHNIQUE: 2.6.4 ELIMINATE FIXTURE SUPPLY VALVES

DESCRIPTION & ECONOMICS OF ADOPTION

The New Technique: - Delete individual fixture water supply valves, with the exception of the toilet.

What It Replaces: - Conventional method is to supply a water shut-off valve at almost every fixture location in the house.

The Savings: - Cost saving would amount to about $3.00 per valve or $27.00 for an average house.

HISTORY & TRADE EXPERIENCE

Market Area/ Application: - Consumers have come to expect shut-off valves at all plumbing fixtures.

CURRENT IMPEDIMENTS/INCENTIVES TO USAGE

General: - The valves are convenient during servicing of a defective fixture. Instead of having a shut-off valve at each fixture; the house service valve can be closed for occasional repair jobs.

Trade Comments: - The use of individual fixture valves is very infrequent (about once every 10 or 20 years). Use of the valve often results in failure of the valve itself, which would have to be replaced at the time of repair.

Code Reference: The Plumbing and Drainage Act Regulations, Part 16, Potable Water System. Amendments required to ABC 1985: _____ Yes __X__ No

OVE TECHNIQUE: 2.6.5 ALTERNATIVE PLASTIC WATER SUPPLY PIPING

DESCRIPTION & ECONOMICS OF ADOPTION

The New Technique:

- Use plastic water supply piping for plumbing installations inside the house and for some types of underground installations.

What It Replaces:

- Copper pipe.

The Savings:

- Polyethylene and polybutylene piping (polytube) are proven materials for providing water service to the house. Their main advantage is reduced material cost. Compared to type K copper pipe, savings are about $1.50 to $2.00 per 300mm (12") length for a 50mm (2") lateral. This would result in a cost saving of about $75.00 for an average sized house.
- Polybutylene supply piping is a flexible material with special fittings recently made available to the plumbing trade and accepted by the Alberta Plumbing Code. This piping costs less than copper and requires less skill to install. Its flexibility allows it to be installed with fewer elbows and joints. Overall installed cost savings compared to copper range from 30% to 50%, which would result in a saving of about $225.00 for an average sized house.
- Chlorinated PVC (CPVC) plastic piping is also available for hot and cold water piping. Generally CPVC pipe costs about 20% to 40% less than copper, however this is partly offset by the higher cost of fittings. Savings in labour range from 25% to 40%. CPVC pipe is not affected by acid water. Since this water condition may be a problem in some locations in Alberta, the use of CPVC piping may be advantageous in these installations. Installed costs of the CPVC piping would be similar to that of the Polybutylene.

HISTORY & TRADE EXPERIENCE

Market Area/ Application:

- PVC plastic is now the most widely and accepted piping being used in Alberta.

OVE TECHNIQUE: 2.6.5 ALTERNATIVE PLASTIC WATER SUPPLY PIPING (cont.)

CURRENT IMPEDIMENTS/INCENTIVES TO USAGE

General:

- Polytube's biggest advantage is its flexibility; it expands and contracts with temperature changes, so it will not crack or break if it freezes. Room for expansion must be provided for each run of pipe.
- The two main disadvantages of polyethylene and polybutylene supply piping are: first, special provisions must be made in hot water lines to allow for expansion and second, individual fittings or clusters of fittings must be cut out and replaced if minor mistakes are made.

Trade Comments:

- Polytube can be pulled through studs and beams so it is good for tight spaces and remodelling work.
- Polytube has the added benefit that solvent welded joints cannot be penetrated by tree roots.

Code Reference: The Plumbing and Drainage Act Regulations.

Amendments required to ABC 1985: _____ Yes __X__ No

TABLE 1

SUMMARY OF INDIVIDUAL OVE TECHNIQUES AND APPLICABLE COST-SAVINGS

REFERENCE	INDIVIDUAL OVE TECHNIQUE	HOUSE SAVING/UNIT
2.1.1	PRESERVED WOOD FOUNDATIONS	$450 - $500
2.1.2	ENGINEERED CONCRETE FOUNDATION DESIGN	$200 - $250
2.1.3	FLOOR SLAB THICKNESS, REINFORCEMENT & FINISHING	$200 - $305
2.2.1	COMBINED EXTERIOR WALL SHEATHING/SIDING	$300
2.3.1	ATTIC VENTING	$ 65
2.4.1	GENERAL OVE FRAMING GUIDELINES (total: $1,835 to $2,045)	-
2.4.2	OVE FLOOR FRAMING	$313
2.4.3	OVE WALL FRAMING	$350
2.4.4	OPTIMUM JOIST LENGTH AND BEAM LOCATION	variable
2.4.5	CANTILEVERED FLOOR AREAS	$275
2.4.6	SINGLE LAYER FLOOR SHEATHING	$ 65 - $280
2.4.7	ELIMINATION OF JOIST BRIDGING	$ 85
2.4.8	SUPPORT OF NON-LOADBEARING PARTITIONS	$ 65
2.4.9	OSB AND PLYWOOD I JOISTS	$ 50 - $115

TABLE 1 (Cont'd)

SUMMARY OF INDIVIDUAL OVE TECHNIQUES AND APPLICABLE COST-SAVINGS

REFERENCE	INDIVIDUAL OVE TECHNIQUE	HOUSE SAVING/UNIT
2.4.10	LAMINATED PLY-BEAMS	$ 45
2.4.11	DRYWALL CLIPS	$200
2.4.12	PARTITION FRAMING - NON-LOADBEARING	$235
2.4.13	FRAMING COORDINATION OF EXTERIOR OPENINGS	$ 85
2.4.14	FRAMING OF INTERIOR DOOR OPENINGS	$ 54
2.4.15	ACCURATE HEADER SELECTION	$ 75
2.5.1	EXTERIOR FINISH AND TRIM	$140
2.5.2	ROOF TRIM DETAILS	$265
2.5.3	REDUCE INTERIOR DOOR AND WINDOW TRIM	$138
2.5.4	CLOSET DOORS AND TRIMS	$ 72
2.6.1	CENTRALIZED PLUMBING & STACK VENTING	$200 - $260
2.6.2	REDUCED DRAIN & VENT PIPE SIZING	$400 - $700
2.6.3	FIBREGLASS BATH MODULES	$ 45
2.6.4	ELIMINATE FIXTURE SUPPLY VALVES	$ 27
2.6.5	ALTERNATIVE PLASTIC WATER SUPPLY PIPING	$ 75 - $225

3.0 COMPARATIVE HOUSE COSTS

3.0 COMPARATIVE HOUSE COSTS

3.1 Why Three Houses?

This portion of the study evaluates the relative cost differences among three houses: the Alberta House Cost Comparison (AHCC) design, the OVE 1 (AHCC design), and finally, the OVE 2 Prototype design. The trade divisions for each house were assembled and the individual material and labour components were estimated for each. Comparisons and conclusions were made of individual trade item costs, and the total cost of each house design was established. The general design drawings and a breakdown of house size, area, volume, and exterior surface area are also included for purposes of comparison.

The cost analysis for the three houses examines the construction cost differences among them. It also highlights the reasons for those differences with reference to such factors as: material costs, labour costs, and building features and inclusions/exclusions related to OVE.

The AHCC and OVE 1 houses were chosen to illustrate direct comparisons between conventional construction and OVE construction. The OVE 2 house demonstrates the potential for an entirely OVE-designed house, including numerous design and marketing features; it is comparable with the other two houses.

Upgraded interior finishes, special finishing features, or extras that relate mainly to market driven forces were purposely avoided in all three houses.

3.2 Scope of Comparison

Cost estimates for these two houses were arrived at by using previous base costing data from the AHCC house, and informal input from builders and various trades. The cost estimates of each of the two single, detached OVE houses include all structural, finishing, mechanical, and electrical work as shown on the drawings and as included in the division descriptions.

A site allowance of $3,000.00 is included in the estimates for all three houses. The estimates exclude the following items:

- cost of land and site clearance
- site servicing costs
- site development costs
- design fees and expenses
- legal fees and expenses
- marketing and real estate financing costs
- appliances: fridge and stove
- general contractor's overhead and profit.

3.3 Alberta House Cost Comparison (AHCC)

Background

- The basic home against which the OVE costs are compared is the 1986 Alberta House Cost Comparison (AHCC) Study, which was originally developed by Alberta Municipal Affairs in 1979. The AHCC house is used to establish base hard costs for conventional construction costs.

- The detailed hard construction costs of the AHCC prototypical single, detached dwelling have been estimated and well documented and are generally accepted in the industry as representing a fairly accurate indicator of current housing costs in the province. Construction costs for Edmonton were used as the basis for comparison for the OVE study. Relative costs for construction of the three comparison houses in other Alberta urban centres could be estimated by using comparative cost ratios contained in the 1986 AHCC study.

- The basic specification features for the AHCC house have not changed greatly over the past several years. Aside from metrification, beam resizing, and thicker, 38 x 140mm (2"x 6") exterior wall studs and added insulation, it has remained essentially the same as originally developed over seven years ago.

3.3 Alberta House Cost Comparison (AHCC)

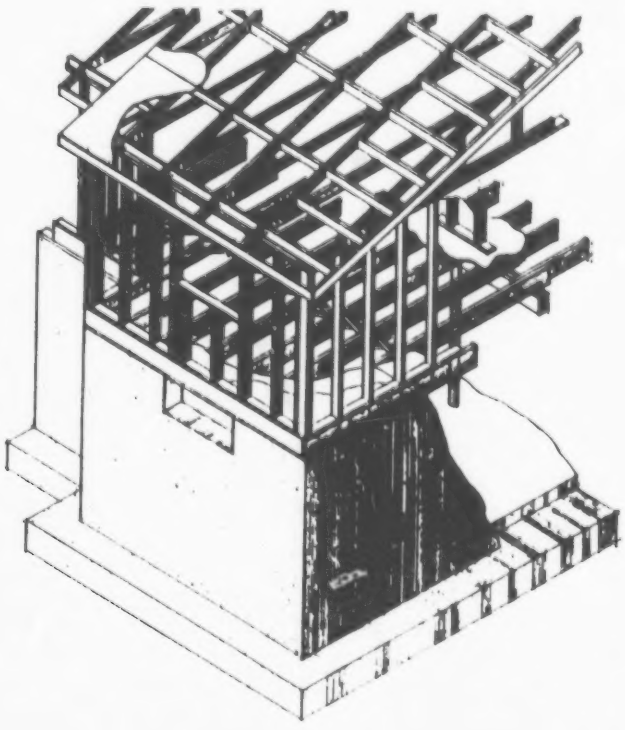
Design

The AHCC house is a single-family, 100 sq. m bungalow with a full and open basement. The basic plan is rectangular in shape with a small 600mm projection of the basement and main floor areas at the front of the house. The total heated volume, including the basement area, is approximately 480 cu. m. The house contains three bedrooms, a living room, combined dining space and kitchen, and a single bathroom. The quality of interior and exterior finishing is considered modest by today's standards.

Comments

No attempt was made to alter the design of the standard AHCC house to any extent since it was intended to be used as a "base" or "bare bones" comparison model for the two OVE houses. Houses being offered now are generally custom designed or a stock plan is modified to suit the individual owner. Houses are also tending to be somewhat larger and more expensively finished.

Builders' associations noted many buyers today are requesting, and receiving, numerous design changes to standard house layouts and materials specifications lists. This affords the potential buyer greater leverage and choice in the marketplace, but can add considerably to the cost to the basic house. It appears home buyers are tending to be more sophisticated and conscious of design quality, specifications and construction techniques.



AHCC ISOMETRIC (Figure 1)

AHCC DESIGN SUMMARY

ROOF

- CONVENTIONAL ROOFS OFTEN INCORPORATE COMPLICATED SHAPES AND WIDE OVERHANGS; THESE ADD SIGNIFICANT LABOUR AND MATERIAL COSTS AND DO NOT ALWAYS HAVE UNIVERSAL APPEAL IN THE MARKETPLACE.
- EXTENSIVE ATTIC VENTING IS NOT REQUIRED WHEN TIGHT INTERIOR CEILING AIR AND VAPOUR SEALS ARE PROVIDED IN NEW HOMES.

WOOD FRAMING

- THE USE OF NON-MODULAR DIMENSIONING AND LACK OF GOOD SITE LAYOUT COORDINATION RESULTS IN MUCH GREATER COSTS ASSOCIATED WITH MATERIAL AND LABOUR USED FOR FRAMING OF FLOORS, WALLS AND ROOFS.
- FLOOR JOISTS SPACED AT 400MM (16") ON CENTRE, OVERLAPPED AT THE BEARING LINES, TOGETHER WITH STANDARD SUBFLOOR AND UNDERLAY, RESULTS IN A COSTLY AND INEFFICIENT USE OF FRAMING MATERIALS. CROSS-BRIDGING IS NORMALLY PROVIDED IN CONVENTIONAL CONSTRUCTION, BUT IS NOT ALWAYS REQUIRED.
- WALL STUDS SPACED AT 400MM (16") ON CENTRE INCREASE THE AMOUNT OF FRAMING LUMBER AND LABOUR USED AND DECREASE OVERALL INSULATION EFFECTIVENESS.
- WOOD CENTRE SUPPORT BEAMS IN CONVENTIONAL CONSTRUCTION ARE OFTEN LOCATED FOR ONLY PLANNING REASONS, RATHER THAN TO MAXIMIZE SPAN BENEFITS AND REDUCE OVERALL JOIST MATERIAL COSTS.

GROUND FLOOR (Figure 2)

AREA : 100 M²
VOLUME : 240 M³

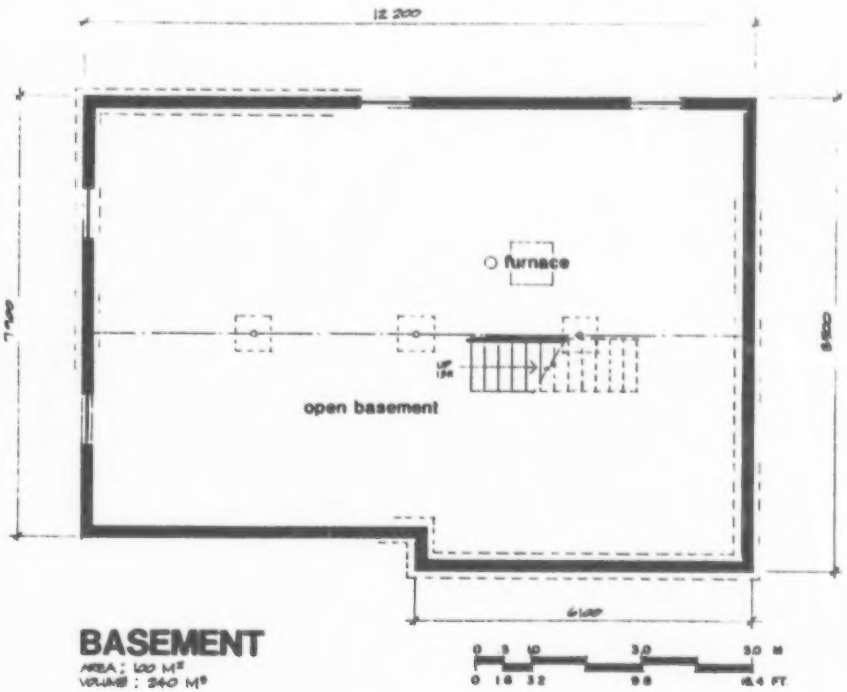
AHCC DESIGN SUMMARY

WOOD FRAMING

- INTERIOR NON-LOADBEARING PARTITIONS ARE USUALLY SUPPORTED BY COSTLY DOUBLE FLOOR JOISTS, THOUGH NOT REQUIRED BY CODE.
- THREE STUDS ARE COMMONLY USED AT WALL CORNERS AND PARTITION INTERSECTIONS; MATERIAL AND LABOUR COSTS ARE HIGHER WHEN WOOD BACKING IS USED FOR DRYWALL.
- DOUBLE TOP PLATES ARE REQUIRED IN CONVENTIONAL CONSTRUCTION BECAUSE LOADS AND STRESSES ARE PLACED ON THE SPACES BETWEEN STUDS; EXTRA FRAMING MATERIAL IS REQUIRED.
- THE USE OF 38 (2") x 89MM (4") WALL STUDS SPACED AT 400MM (16") ON CENTRE FOR INTERIOR, NON-LOADBEARING PARTITIONS WASTES MATERIAL AND ADDS 25MM (1") TO TO THE CLEAR DIMENSIONS OF EACH ROOM.
- THE PLACEMENT OF WINDOWS AND DOORS OFTEN REQUIRE THE USE OF NUMEROUS HEADERS, JACK STUDS AND CRIPPLES. INTERIOR OPENINGS ARE OFTEN HANDLED IN A SIMILAR FASHION, EVEN THOUGH THEY DO NOT SUPPORT STRUCTURAL LOADS.
- ROOF SHEATHING COSTS ARE HIGHER WHEN LAYOUT PRE-PLANNING, MATERIAL SELECTION, AND COST-SAVING APPLICATION METHODS ARE IGNORED.

SIDING

- CONVENTIONAL EXTERIOR FINISHING USUALLY CONSISTS OF SEPARATE SHEATHING AND SIDING MATERIALS, APPLIED IN TWO OPERATIONS AND BY TWO DIFFERENT TRADES. SHEATHING MAINLY PROVIDES STRUCTURAL RIGIDITY TO THE WOOD FRAME, AND ACTS AS A COSTLY BACKING FOR A SEPARATE EXTERIOR FINISH.



(Figure 3)

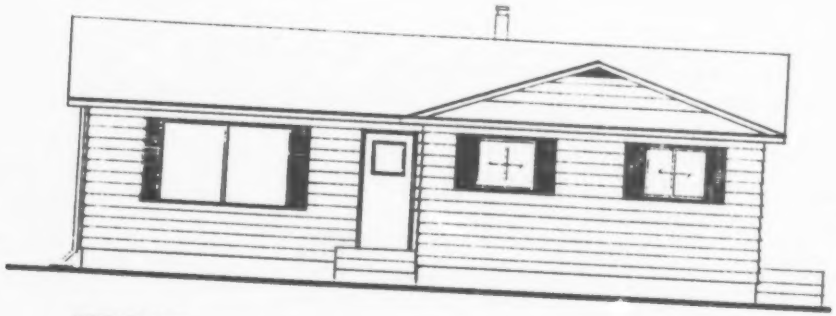
AHCC DESIGN SUMMARY

CONCRETE

- DIMENSIONS ESTABLISHED FOR THE FOUNDATION OF THE STRUCTURE OFTEN SET THE SIZE OF THE MAIN AND/OR UPPER FLOORS, REGARDLESS WHETHER THEY ARE ON-MODULE OR NOT. WASTEAGE COSTS OF THE WOOD FRAMING AND SHEATHING ARE INCREASED WITH THIS METHOD OF CONSTRUCTION, SINCE MORE MATERIAL IS ORDERED AND MUCH OF THE MATERIAL MUST BE SITE CUT AND DISCARDED.
- COMPLICATED FOUNDATION SHAPES AND NUMEROUS CORNERS ADD CONSIDERABLE COST TO CONVENTIONAL CONCRETE FOUNDATION INSTALLATIONS.
- WALL OR FOOTING SIZES IN CONVENTIONAL CONSTRUCTION ARE OFTEN RELATED TO TRADITION RATHER THAN ON ACTUAL SITE AND SOIL CONDITIONS.

FOUNDATION

- SELECTION OF THE FOUNDATION DESIGN FOR CONVENTIONAL CONSTRUCTION IS OFTEN BASED ON THAT USED ON PREVIOUS HOUSES IN A SUBDIVISION OR BY OVER-DESIGN, RATHER THAN ON FACTORS SUCH AS CLIMATE, SOIL, TOPOGRAPHY, AND ACTUAL BUILDING LOADS.
- MISTAKES MADE AT THE LAYOUT STAGE ARE IMPORTANT; THEY CAN INCREASE LABOUR COSTS AND MATERIALS WASTE DURING SUBSQUENT FRAMING OPERATIONS.



FRONT (Figure 4)

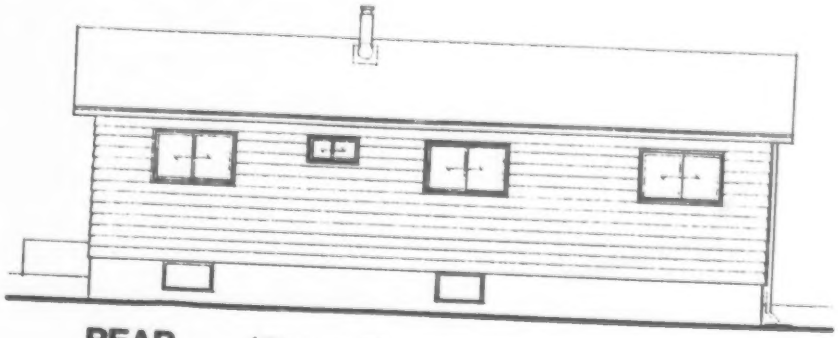
AHCC DESIGN SUMMARY

FINISHING

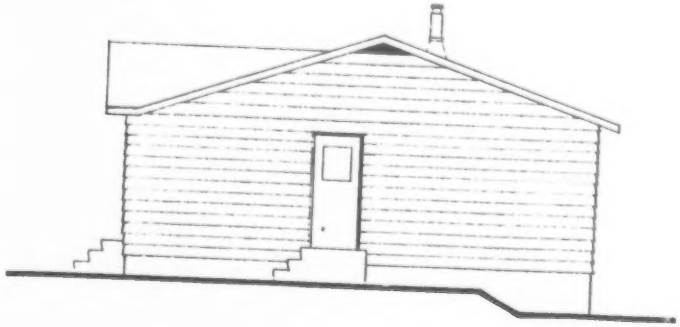
- TRADITIONAL INTERIOR AND EXTERIOR SITE PAINTING CAN BE HIGH WHEN PREFINISHED PRODUCTS AND METHODS ARE NOT USED. EXPENSIVE LUMBER TRIM OR COMPLICATED DETAILING ARE OFTEN USED WHERE NOT VISIBLE OR APPRECIATED.
- CONVENTIONAL DETAILING TYPICALLY MAKES USE OF COSTLY CLOSED, PREFINISHED ALUMINUM SOFFIT OVERHANGS. ALUMINUM FASCIAS, SOFFITS, AND TRIMS CAN ALSO ADD CONSIDERABLE COST TO AN AVERAGE HOUSE.
- INTERIOR PAINTED WOOD TRIMS AT DOORS AND WINDOWS ARE USED MOST OFTEN IN TYPICAL HOME CONSTRUCTION; SITE FINISHING AND PAINTING ADD ADDITIONAL COST.

DOORS AND WINDOWS

- WINDOWS ARE COMMONLY MANUFACTURED IN NON-MODULAR SIZES; WOOD WALL FRAMING MUST BE ADJUSTED TO SUIT VARIOUS SIZES AND SHAPES FOR EACH HOUSE AND INTERFERE WITH THE UNINTERRUPTED USE OF MODULAR COMPONENTS.
- THE USE OF PRE-HUNG AND PREFINISHED EXTERIOR METAL DOOR UNITS IS NOW FAIRLY COMMON IN THE INDUSTRY.
- LABOUR INTENSIVE HANGING AND FINISHING OF INTERIOR DOOR AND CLOSET UNITS ADDS ON-SITE LABOUR COSTS TO THE AVERAGE HOUSE. SITE FINISHED CLOSET SHELVING IS ALSO MORE EXPENSIVE.



REAR (Figure 5)



SIDE

DRYWALL & PAINTING

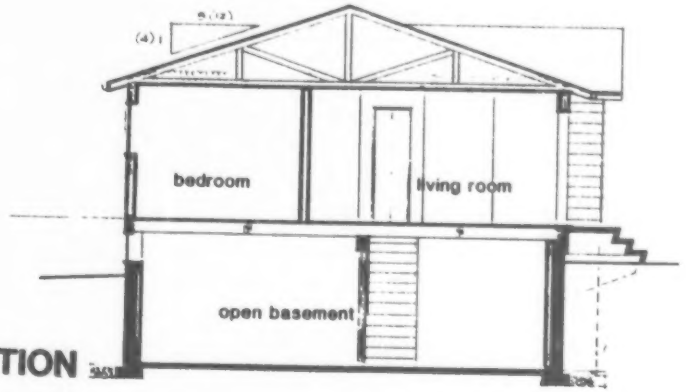
- THE USE OF STANDARD 1200MM (4') x 2400MM (8') DRYWALL SIZES CAN RESULT IN MORE JOINTS TO FILL AND FINISH, THUS ADDING COSTS TO LABOUR AND INSTALLATION FOR AN AVERAGE HOUSE.
- TRADITIONAL WOOD BLOCKING FOR DRYWALL BACKING LOWERS INSULATION LEVELS AND ADDS COSTS IN LABOUR AND MATERIALS.

PLUMBING

- RANDOM LOCATION OF PLUMBING FIXTURES ADDS COSTS TO PIPING REQUIREMENTS BECAUSE OF LONGER AND MORE COMPLICATED RUNS.
- CERAMIC TILE IS USED EXTENSIVELY AT TUB AND SHOWER SURROUNDS AND OFTEN RESULTS IN WATER LEAKS AND EVENTUAL CALLBACKS.

HEATING

- HEATING EQUIPMENT SELECTION IN CONVENTIONAL HOMES IS OCCASIONALLY DONE ON THE BASIS OF TRADITION OR JUDGEMENT, INSTEAD OF BY DETAILED, ROOM BY ROOM HEAT-LOSS CALCULATIONS. NATURAL GAS MAY NOT ALWAYS BE THE MOST COST EFFECTIVE HEATING SOURCE FOR HOMES IN NON-URBAN AREAS.
- WITHOUT PREPLANNING, THE MECHANICAL SYSTEM AND DUCT AND FLUE CHASES CAN CAUSE HIGHER COSTS FOR CUTTING THROUGH STRUCTURAL MEMBERS.
- CONVENTIONAL EXHAUST DUCTS AND FANS ARE COMMONLY PROVIDED FOR BATHROOMS AND KITCHENS; THESE ADD COST AND ARE ENERGY INEFFICIENT.



SECTION

(Figure 6)

AHCC DESIGN SUMMARY

ELECTRICAL

- DOUBLE AND TRIPLE-POLE SWITCHING, COMPLICATED WIRING RUNS, AND UNNECESSARY OUTLETS, LIGHT FIXTURES, AND FAN SWITCHING CAN ADD ELECTRICAL MATERIAL AND LABOUR COSTS TO AN AVERAGE HOME.
- BRANCH LIGHTING CIRCUITING, HEAVIER THAN REQUIRED WIRING, AND 'SCATTERED' LOCATIONS OF HEAVY LOAD ELECTRICAL ITEMS CAN ADD UNNECESSARY COSTS TO A TYPICAL HOME.
- 200 AMP LOAD CENTRES SHOULD BE NOT BE INSTALLED IN SMALL HOMES.

3.4 OVE 1 - AHCC Design

General Description

The second comparison house, called the OVE 1 (AHCC design), is of the basic AHCC design, but with various OVE related measures such as wall and floor framing, and some finishing techniques applied to it. Not all OVE measures could be incorporated in the first OVE house without altering the basic design of the original AHCC house. Measures were therefore chosen to allow the layout and appearance of the AHCC house to remain. The size, layout, and shape are basically the same as the original AHCC design. This allows a fair comparison of labour and materials costs for each of the first two houses.

Design

Like the previous house, the OVE 1 (AHCC design) is a single-family, 100 sq. m bungalow with a full and open basement. The basic foundation plan is rectangular in shape with a small 600mm (24") cantilever of the main floor at the front of the house. The total heated volume, including the basement area, is approximately 459 cu. m. The house contains three bedrooms, a living room, dining space, kitchen, and bathroom. The quality of interior and exterior finishing is considered modest and in keeping with the AHCC design.

3.4 OVE 1 - AHCC
Design

Comments

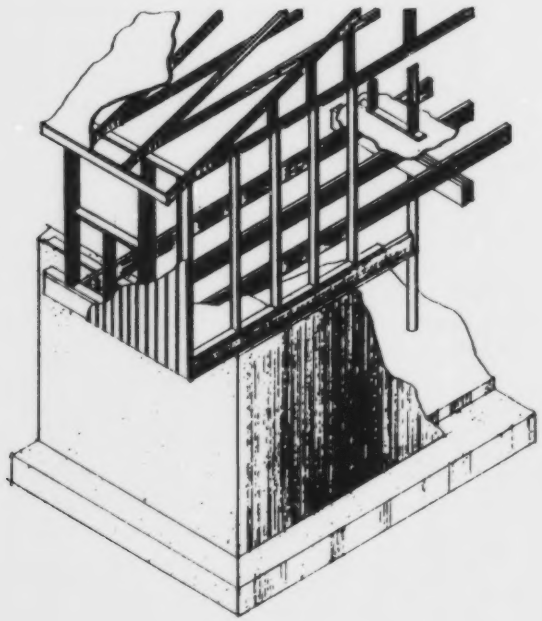
Costs of labour and materials were estimated on the basis of the OVE techniques applied to the basic design and a trade division format was developed along the lines of the past AHCC studies. While material quantities and costs are fairly straightforward, the labour component of calculations required more consideration. Various trades were therefore contacted and estimates made for the labour portions of each OVE technique.

Conclusion

The research into OVE and non-OVE houses allows individual cost inputs into each to be analyzed, compared and contrasted.

"GENERALLY, IT WAS FOUND THAT THE OVE DESIGNED HOUSE ACHIEVED A TOTAL COST SAVING OF APPROXIMATELY 10%. THIS WOULD GIVE A BUILDER ONE FREE HOUSING UNIT FOR EVERY TEN BUILT."

In addition to a significant cost savings on an OVE designed-house, it is reasonable to expect the OVE system could be easily adapted to other housing types and styles such as duplexes, row housing and low-rise apartments. The effect of applying OVE techniques to the average single-family home should not be to label the house as an "OVE design" in appearance or quality of finish. The goal should be to incorporate techniques that have been proven to be cost effective and which are visually and functionally acceptable to the marketplace.



OVE - 1 ISOMETRIC

(Figure 7)

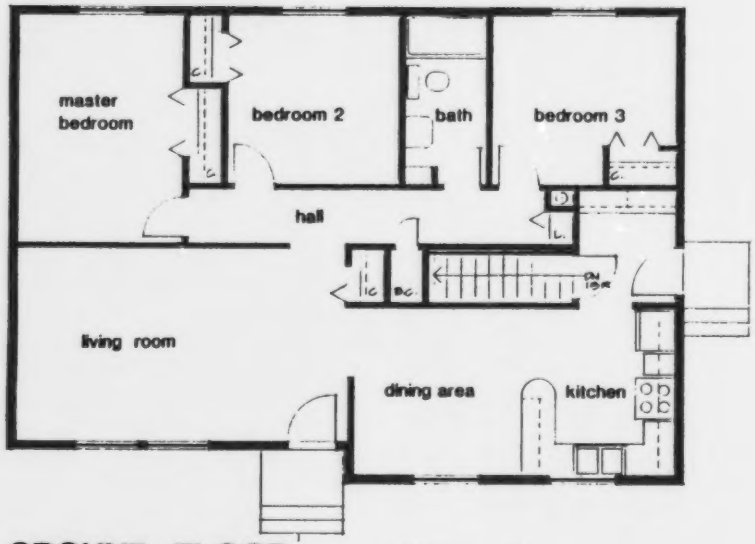
OVE 1 - AHCC DESIGN SUMMARY

ROOF

- ASPHALT ROOF SHINGLES, COMBINED WITH SIMPLE ROOF SHAPES ALLOW GREATEST COST BENEFITS AND LABOUR SAVINGS.
- ATTIC VENTING CAN BE SIMPLIFIED GREATLY WHEN TIGHT INTERIOR CEILING AIR AND VAPOUR SEALS ARE PROVIDED.

WOOD FRAMING

- THE USE OF MODULAR DIMENSIONING AND COORDINATION IS THE MOST IMPORTANT CONSIDERATION WHEN FRAMING IN OPTIMUM VALUE ENGINEERING. UP TO 50% LESS DIMENSION FRAMING LUMBER IS REQUIRED WITH THE OVE SYSTEM BECAUSE ALL FRAMING FOR FLOORS, WALLS AND ROOFS IS SPACED AT 600MM (24") ON CENTRE AND ARE IN VERTICAL ALIGNMENT.
- FLOOR JOISTS SPACED AT 600MM (24") ON CENTRE, BUTTED END FOR END AT THE BEARING LINES, TOGETHER WITH T & G SUBFLOOR GLUED AND NAILED, GIVES A VERY RIGID AND ECONOMICAL FLOOR SYSTEM. CROSS-BRIDGING CAN BE SAFELY ELIMINATED.
- WALL STUDS AND ROOF TRUSSES SPACED AT 600MM (24") ON CENTRE REDUCE THE AMOUNT OF FRAMING LUMBER AND LABOUR NEEDED AND INCREASE INSULATION EFFECTIVENESS. PREFABRICATED GABLE ENDS CUT DOWN ON SITE LABOUR COSTS AND SPEED ERECTION ON SITE.
- WOOD CENTRE SUPPORT BEAMS CAN BE LOCATED FOR MAXIMUM SPAN BENEFITS AND REDUCED JOIST MATERIAL COSTS.



GROUND FLOOR

AREA: 100 M²
VOLUME: 224 M³

(Figure 8)

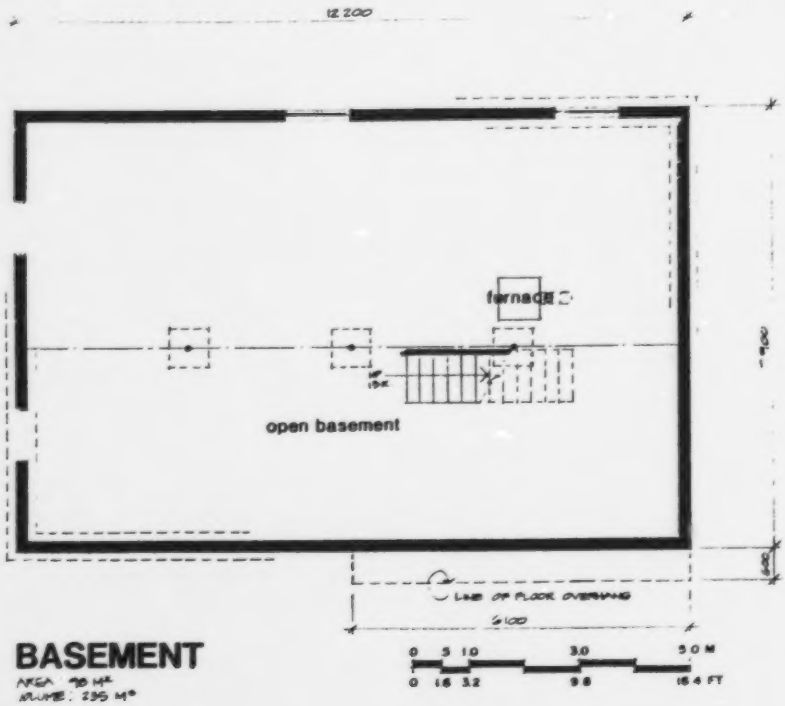
OVE 1 - AHCC DESIGN SUMMARY

WOOD FRAMING

- INTERIOR NON-LOADBEARING PARTITIONS CAN BE SUPPORTED BY INEXPENSIVE, WOOD FURRING RATHER THAN WITH COSTLY DOUBLE FLOOR JOISTS.
- BAND JOISTS CAN BE REDUCED IN SIZE SINCE OVE PLANNING DOES NOT PLACE ANY LOADS OR STRESSES ON THE SPACES BETWEEN JOISTS.
- ONE OF THE THREE STUDS COMMONLY USED AT WALL CORNERS AND PARTITION INTERSECTIONS CAN BE ELIMINATED WHEN DRYWALL CLIPS ARE USED INSTEAD OF SOLID WOOD BACKING.
- THE USE OF 38 (2") x 64MM (3") WALL STUDS SPACED AT 600MM (24") ON CENTRE FOR INTERIOR, NON-LOADBEARING PARTITIONS SAVES MATERIAL AND ADDS 25MM (1") BACK TO THE CLEAR DIMENSIONS OF EACH ROOM.
- THE PLACEMENT OF WINDOWS AND DOORS CAN BE COORDINATED WITH THE 600MM (24") OVE PLANNING MODULE. UNNECESSARY HEADERS, JACK STUDS AND CRIPPLES CAN BE ELIMINATED. INTERIOR OPENINGS CAN BE HANDLED IN A SIMILAR FASHION FOR EVEN MORE SAVINGS.
- ROOF SHEATHING COSTS CAN BE LOWERED BY PROPER LAYOUT PRE-PLANNING, MATERIAL SELECTION AND APPLICATION METHODS.

SIDING

- SINGLE LAYER PANEL TYPE PREFINISHED SIDING SHOULD BE CONSIDERED AS AN ALTERNATIVE TO SEPARATE SHEATHING AND SITE-APPLIED EXTERIOR FINISHES. SINGLE LAYER SIDING CAN BE INSTALLED DIRECTLY TO THE STUDS AND CAN BE ORDERED PREFINISHED, THUS SAVING ON-SITE LABOUR TIME AND ADDING TO QUALITY CONTROL.



(Figure 9)

OVE 1 - AHCC DESIGN SUMMARY

CONCRETE

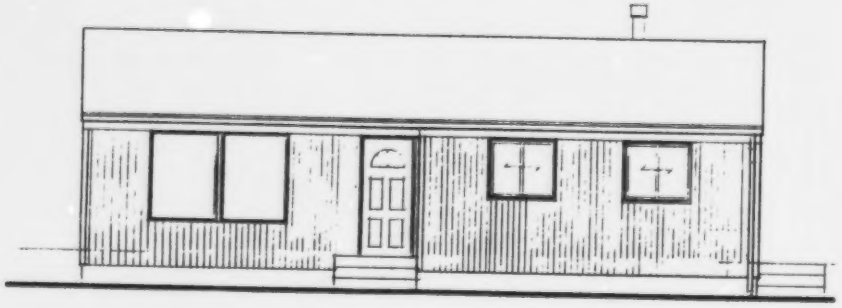
- MODULAR OVE DIMENSIONS ESTABLISHED FOR THE MAIN AND/OR UPPER FLOORS OF THE STRUCTURE SHOULD SET THE SIZE OF THE FOUNDATION.
- WALL OR FOOTING SIZES SHOULD BE RELATED TO ACTUAL SITE AND SOIL CONDITIONS, RATHER THAN BASED ON TRADITION OR OVER-DESIGNED TO SUIT THE SINGLE WORST CASE SCENARIO.
- CONCRETE FLOOR SLABS PLACED ON A WELL-COMPACTED BASE CAN BE OF MINIMUM 75MM (3") THICKNESS. WELDED WIRE MESH IS OF QUESTIONABLE VALUE IN ELIMINATING CRACKS. CONCRETE FLOATING AND FINISHING CAN BE SIMPLIFIED BY STUBBING PLUMBING RISERS FLUSH WITH THE SLAB.

FOUNDATION

- THE SELECTION OF THE FOUNDATION DESIGN AND TYPE FOR OVE CONSTRUCTION IS BASED ON A VARIETY OF FACTORS, SUCH AS CLIMATE, SOIL, TOPOGRAPHY, AND BUILDING LOADS. ACCURACY OF LAYOUT IS IMPORTANT; THIS WILL INCREASE LABOUR PRODUCTIVITY AND MINIMIZE MATERIALS WASTE DURING WOOD FRAMING OPERATIONS.
- PRESERVED WOOD FOUNDATIONS ARE SUITABLE FOR CONSTRUCTION IN COLD CLIMATES, HAVE SUPERIOR INSULATION VALUES, AND HAVE THE ADDED POTENTIAL FOR OVE DESIGNED PREFABRICATION.

FINISHING

- INTERIOR PAINTED WOOD TRIMS AT DOORS AND WINDOWS CAN BE MINIMIZED OR ELIMINATED BY RETURNING THE DRYWALL AT THE HEADS AND JAMBS.



FRONT (Figure 10)

OVE 1 - AHCC DESIGN SUMMARY

FINISHING

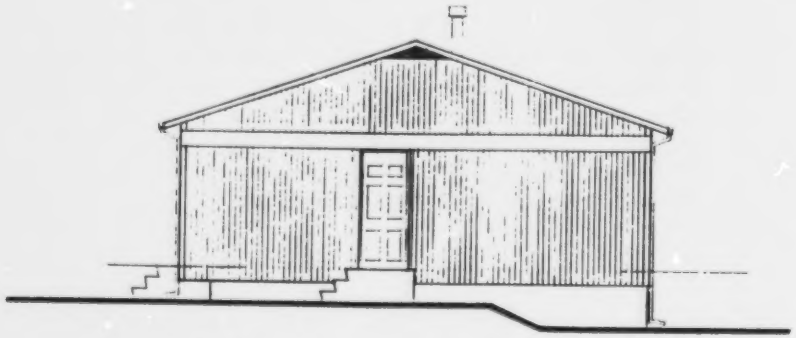
- TIME SPENT ON TRADITIONAL INTERIOR AND EXTERIOR SITE PAINTING CAN BE LOWERED WHEN PREFINISHED PRODUCTS AND METHODS ARE SUBSTITUTED. LESS EXPENSIVE STAINED LUMBER TRIM OR PLASTIC MOLDINGS CAN BE USED EFFECTIVELY IN CONJUNCTION WITH SIMPLER DETAILING METHODS.
- CONSIDER THE USE OF OPEN SOFFIT OVERHANGS WITH STAINED FINISHES, SIMPLIFIED RAKE TRIMS AND THE USE OF LESS EXPENSIVE LUMBER FOR ALL ROOF TRIM DETAILS.

DOORS AND WINDOWS

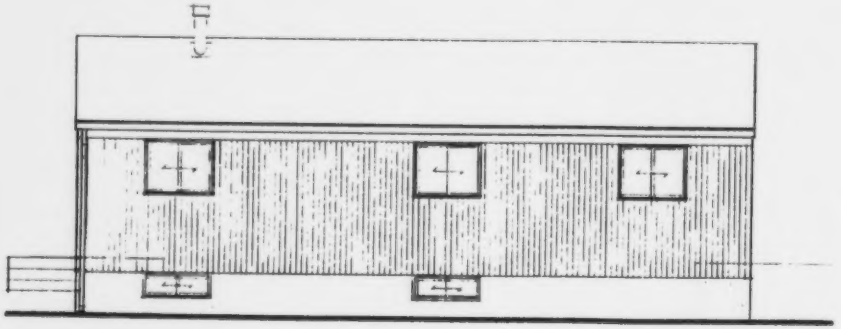
- WINDOW MANUFACTURERS CAN PRODUCE CUSTOM SIZES OF WINDOWS TO SUIT THE 600MM (24") OVE PLANNING MODULE AT LITTLE OR NO EXTRA COST. MOST WINDOWS ARE MANUFACTURED ON A LOCAL OR REGIONAL LEVEL.
- THE USE OF PRE-HUNG AND PREFINISHED EXTERIOR METAL DOOR UNITS IS RECOMMENDED IN OVE CONSTRUCTION TO SIMPLIFY CONSTRUCTION AND MAINTAIN QUALITY CONTROL ON SITE.
- PRE-HUNG AND PREFINISHED INTERIOR DOOR AND CLOSET UNITS SAVE ON-SITE LABOUR COSTS AND ARE CONSISTENT WITH THE BASIC OVE CONCEPT. PREFINISHED CLOSET SHELVING IS ALSO COST EFFECTIVE.

DRYWALL & PAINTING

- THE USE OF MAXIMUM DRYWALL SIZES RESULTS IN FEWER JOINTS TO FILL AND FINISH, THUS SAVING IN LABOUR AND INSTALLATION.



SIDE (figure 11)



REAR

OVE 1 - AHCC DESIGN SUMMARY

DRYWALL & PAINTING

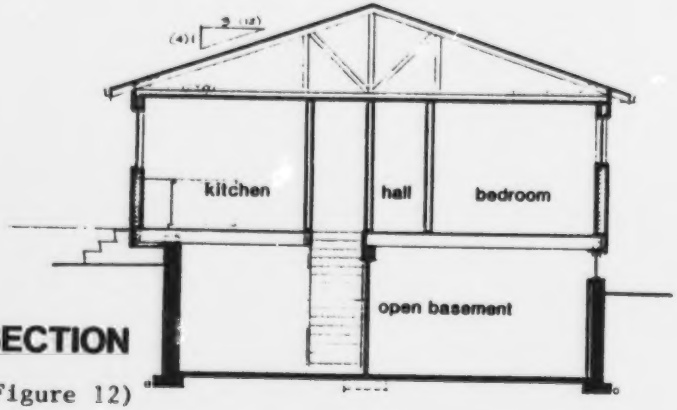
- DRYWALL CLIPS USED TO REPLACE TRADITIONAL WOOD BLOCKING ALLOWS BETTER INSULATION LEVELS AND SAVINGS IN LABOUR AND MATERIALS.

PLUMBING

- BACK-TO-BACK OR CLUSTER PLUMBING INSTALLATIONS MINIMIZE PIPING REQUIREMENTS AND PROVIDE SUBSTANTIAL COST SAVINGS.
- ALTERNATIVE, LOWER COST PIPING MATERIALS SUCH AS PVC OR ABS CAN BE CONSIDERED FOR ABOVE GROUND DWV INSTALLATIONS. CPVC OR POLYBUTYLENE SUPPLY PIPING AND FITTINGS CAN ALSO BE COST EFFECTIVE, PERFORM WELL, AND ARE NOW ACCEPTED BY THE CODE.
- SHUT-OFF VALVES AT ALL FIXTURES MAY NOT BE NECESSARY FOR A TYPICAL HOUSE.
- FIBREGLASS TUB AND SHOWER SURROUNDS CAN REPLACE TRADITIONAL CERAMIC TILE INSTALLATIONS, RESULTING IN FEWER LEAKS AND CALLBACKS.

HEATING

- HEATING EQUIPMENT SELECTION SHOULD BE DONE ON THE BASIS OF A DETAILED, ROOM BY ROOM HEAT-LOSS CALCULATION RATHER THAN JUST TRADITION OR JUDGEMENT. COST EFFECTIVE ALTERNATE HEATING SOURCES FOR HOMES IN NON-URBAN AREAS SHOULD BE INVESTIGATED.
- PREPLANNING OF THE MECHANICAL SYSTEM AND DUCT AND FLUE CHASES CAN ELIMINATE THE COST OF CUTTING THROUGH STRUCTURAL MEMBERS.



SECTION

(Figure 12)

OVE 1 - AHCC DESIGN SUMMARY

HEATING

- WHERE DUCTWORK IS NOT REQUIRED TO BE CONCEALED, A SIMPLE RADIAL DUCT SYSTEM CAN BE USED AS A COST SAVING MEASURE.
- EXHAUST DUCT ELIMINATION FOR BATHROOMS AND KITCHENS CAN BE CONSIDERED WHERE PRACTICAL. ENERGY SAVINGS ARE AN ADDED BENEFIT.

ELECTRICAL

- SINGLE-POLE SWITCHING, SIMPLIFIED WIRING RUNS, AND THE ELIMINATION OF UNNECESSARY OUTLETS, LIGHT FIXTURES, AND FAN SWITCHING CAN PROVIDE CONSIDERABLE ELECTRICAL COST SAVINGS.
- BRANCH LIGHTING CIRCUITING, HEAVIER THAN REQUIRED WIRING, AND 'SCATTERED' LOCATIONS OF HEAVY LOAD ELECTRICAL ITEMS CAN ADD UNNECESSARY COSTS TO A TYPICAL HOME.
- A MINIMUM SIZE, 100 AMP LOAD CENTRE CAN BE ADEQUATE IN SMALL HOMES.

3.5 OVE 2 - Prototype Design

General Description

The third house, the OVE 2 Prototype, was conceived and designed as an OVE house utilizing a maximum number of the researched cost saving techniques. Since OVE innovation would have to compete in the Alberta marketplace with non-OVE housing, the OVE 2 Prototype has also been designed as an initial response to reflect current Alberta market preferences.

It is not intended that the OVE 2 Prototype be marketed as a universal design; it is intended, rather to illustrate OVE principles in prototype form. Variety, change and innovation of design are, as always, the keystones of the new home market. No single design can, or should, be promoted as the end-all for every application or market need. Designs which incorporate innovation, flexibility, and functional layouts, combined with attractive exterior appearances, will always be desired in the Alberta marketplace.

The OVE 2 Prototype house is a single-family, 112 sq. m one and one-half storey design with a full and open basement. The basic plan is square in shape with portions of the main floor allowed to cantilever in certain locations. The total heated volume, including the basement area, is approximately 474 cu. m. The house contains three bedrooms, a living room, dining space, kitchen, and two bathrooms.

3.5 OVE 2 - Prototype Design

General Description

The OVE 2 house has also been designed to allow for future growth and alternate interior plan layouts to suit owner's needs. The quality of interior and exterior finishing is considered modest and is in keeping with the two previous designs.

The general material and labour components for the OVE 2 Prototype include many of the items listed in the individual cost comparison sheets. The OVE techniques utilized in this house go beyond those incorporated in the OVE 1 design and relate to many of the design issues in today's marketplace.

Comments

The OVE 2 Prototype is intended to illustrate the possibilities of a more aggressive OVE approach to a modest house. It also attempts to respond to the realities of the current Alberta marketplace, such as the desire for larger and more open floor areas, options for the change or alternative use of certain rooms, and the allowance for a planned future growth of the house.

Costs of labour and materials for the OVE 2 Prototype were estimated on the basis of the OVE techniques applied to the new prototype design and a trade division format was again developed along the lines of the AHCC study and from costing information from local builders.

3.5 OVE 2 - Prototype Design

Comments

The OVE 2 Prototype is approximately 12 sq. m larger than the standard AHCC house design. The increased size allows the house to be more flexible in terms of room area use and also gives much needed space to a number of the rooms. The main floor bedroom can be used alternatively as a den or separate dining room and with the removal of a short piece of wall, can be converted into a family room. The second floor has the capability of accommodating two bedrooms or being converted into a den, open studio/loft, or any combination of these elements. Because of the nature of the one and one-half storey design, it was decided to include a main floor bathroom into the design. This inclusion was considered necessary by all builders interviewed.

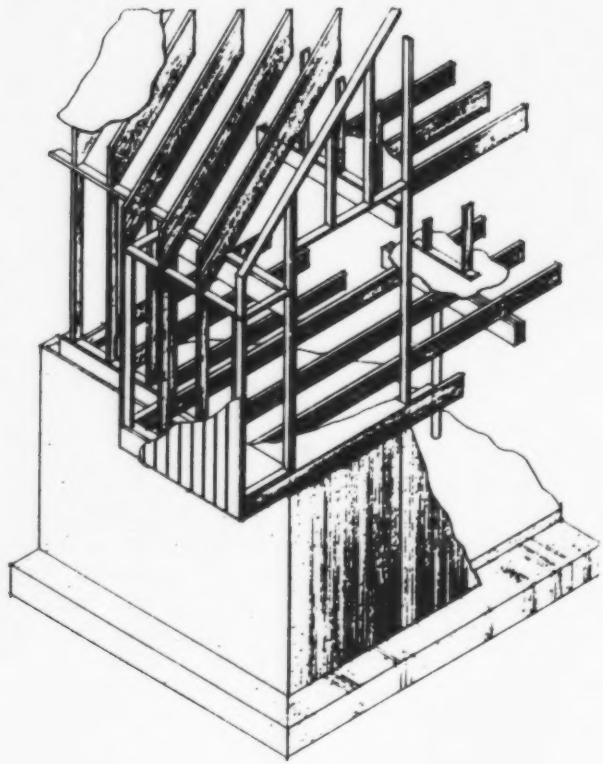
With reference to the specific layout of the OVE 2 Prototype, comments received from builders indicated the market preference is towards custom design or extensive modifications to a stock house design. Since house buyers are demanding more flexibility in the floor plans, the OVE 2 Prototype allows alternative uses of rooms or areas of the house with minimal changes to the basic framing and the structural shell. Builders' associations indicated that savings related to engineering charges for redesign or custom layouts can be significant to the average house builder. Any effort to lessen or eliminate the potential for additional design and engineering costs is therefore deemed positive.

3.5 OVE 2 - Prototype Design

Conclusions

If buildings can be initially designed to include and maximize OVE techniques, cost savings should be much greater than if techniques are just applied to an existing stock house design. An added benefit to an OVE-based design, such as the OVE 2 Prototype, is that design quality and market appeal can be enhanced, at the same time that cost saving measures are being applied by a builder. This is accomplished by introducing OVE measures into the house design at the time of early planning and when materials are first selected. There is greater potential for benefits to be passed on to both the builder and the home buyer in such a situation.

In the case of the OVE 2 Prototype, it would be possible to build a larger, better designed and more appealing house for approximately the same cost as a non-OVE house having minimal market appeal.



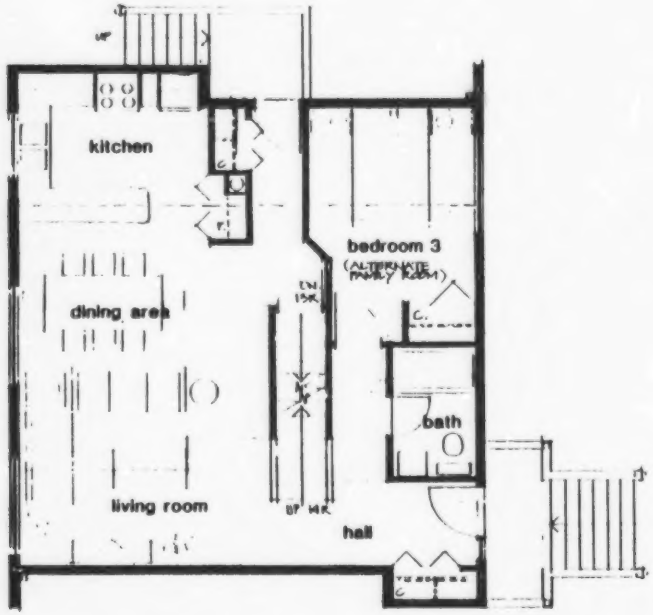
OVE - 2 ISOMETRIC

(Figure 13)

OVE 2 - PROTOTYPE SUMMARY

BASIC APPROACH

- THE OVE 2 PROTOTYPE HOUSE DESIGN PROVIDES FOR BASIC KITCHEN, DINING AREA, LIVING AREA, BATHROOM(S) AND THREE BEDROOMS, ALL IN KEEPING WITH CURRENT CONSUMER ENTRY LEVEL MARKET PREFERENCE. THE PROTOTYPE WAS DEVELOPED AS A DIRECT COMPARABLE TO THE STANDARD 1986 ALBERTA COST COMPARISON HOUSE.
- THE USE OF MODULAR DIMENSIONING AND COORDINATION IS THE MOST IMPORTANT CONSIDERATION WHEN FRAMING IN OPTIMUM VALUE ENGINEERING. UP TO 50% LESS DIMENSION FRAMING LUMBER IS REQUIRED WITH THE OVE SYSTEM BECAUSE ALL FRAMING FOR FLOORS, WALLS AND ROOFS IS SPACED AT 600MM (24") ON CENTRE AND ARE IN VERTICAL ALIGNMENT.
- FLOOR JOISTS SPACED AT 600MM (24") ON CENTRE, BUTTED END FOR END AT THE BEARING LINES, TOGETHER WITH T & G SUBFLOOR GLUED AND NAILED, GIVES A VERY RIGID AND ECONOMICAL FLOOR SYSTEM. CROSS-BRIDGING CAN BE SAFELY ELIMINATED.
- WALL STUDS AND ROOF TRUSSES SPACED AT 600MM (24") ON CENTRE REDUCE THE AMOUNT OF FRAMING LUMBER AND LABOUR NEEDED AND INCREASE INSULATION EFFECTIVENESS. PREFABRICATED GABLE ENDS CUT DOWN ON SITE LABOUR COSTS AND SPEED ERECTION ON SITE.
- THE MAJORITY OF THE BASIC OVE MEASURES OUTLINED IN THE OVE 1 HOUSE DESIGN HAVE BEEN INCORPORATED IN THE OVE 2 PROTOTYPE DESIGN. FURTHER PLANNING AND DESIGN ELEMENTS HAVE ALSO BEEN INCLUDED.



MAIN FLOOR (Figure 14)

AREA : 74 M²
VOLUME : 168 M³

OVE 2 - PROTOTYPE SUMMARY

DESIGN CONCEPTS

- THE MAJOR ORIENTATION OF THE LIVING AREAS AND KITCHEN ARE TOWARDS THE BACKYARD, OR PRIVATE OUTDOOR SPACE, RATHER THAN TO ADJACENT LOTS, HOUSES, OR TOWARDS THE STREET IN FRONT OF THE HOUSE.
- THE HOUSE CAN BE BUILT ON A NARROW 11 M (36') WIDE SITE. THE HOUSE IS ALSO WELL SUITED TO IN-FILL TYPE LOTS FOUND IN THE MORE MATURE AREAS OF A TOWN OR CITY.
- SECOND FLOOR WINDOWS ARE ORIENTED TOWARDS THEIR OWN PATIO AND PRIVATE VIEWS, RATHER THAN TO ADJACENT SIDEYARDS.
- SLOPED CEILINGS AT THE MAIN FLOOR AREA PROVIDE A MORE SPACIOUS FEEL TO THE HOUSE INTERIOR AND ADD INTEREST TO THE OVERALL DESIGN; TOTAL HOUSE VOLUME HAS NOT BEEN INCREASED AS A RESULT. AN OPEN SECOND FLOOR INTERIOR BALCONY IS LOCATED AT THE TOP OF THE STAIR FOR THE SAME DESIGN REASONS.
- THE PROVISION OF A BEDROOM AT THE MAIN FLOOR ALLOWS THE HOUSE TO BE USED BY THE ELDERLY AND DISABLED WITH LITTLE OR NO CONVERSION WORK. THE DESIGN ALLOWS FOR DIFFERING FAMILY UTILIZATION AND CHANGE OF USE AND FUNCTION OVER TIME.

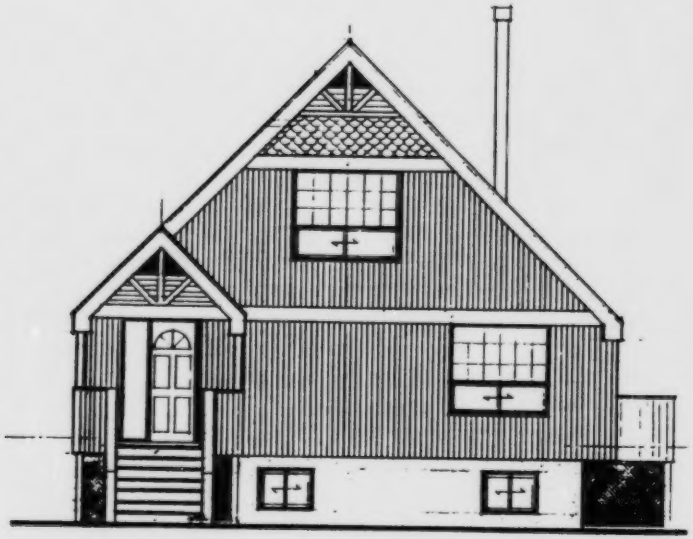
SECOND FLOOR (Figure 15)

AREA : 98 M²
VOLUME : 120 M³

OVE 2 - PROTOTYPE SUMMARY

DESIGN CONCEPTS

- THE FRONT ENTRY AREA PROVIDES WEATHER PROTECTION FOR THE REMAINDER OF THE MAIN FLOOR AND PARTICULARLY FOR THE LIVING ROOM. AN ADDITIONAL INTERIOR DOOR COULD BE EASILY ADDED TO CONVERT THE SPACE INTO AN "ENTRY LOCK" AREA.
- THE OUTSIDE PORCH, STAIR AND DECK AREA IS PROVIDED WITH A ROOF COVERING OVER AND HELPS TO DEFINE THE MAIN ENTRANCE TO THE HOUSE.
- A COMBINED CLOSET/PANTRY UNIT HAS BEEN PROVIDED IN THE KITCHEN AND IS CONSTRUCTED IN A PARTITION WALL RATHER THAN AS A SEPARATE, MORE COSTLY PIECE OF KITCHEN CABINET OR MILLWORK.
- THE KITCHEN AREA IS POSITIONED CLOSE TO THE MECHANICAL AND ELECTRICAL EQUIPMENT LOCATED IN THE BASEMENT; THIS ENSURES SHORTER AND MORE ECONOMICAL RUNS OF PIPING AND WIRING.

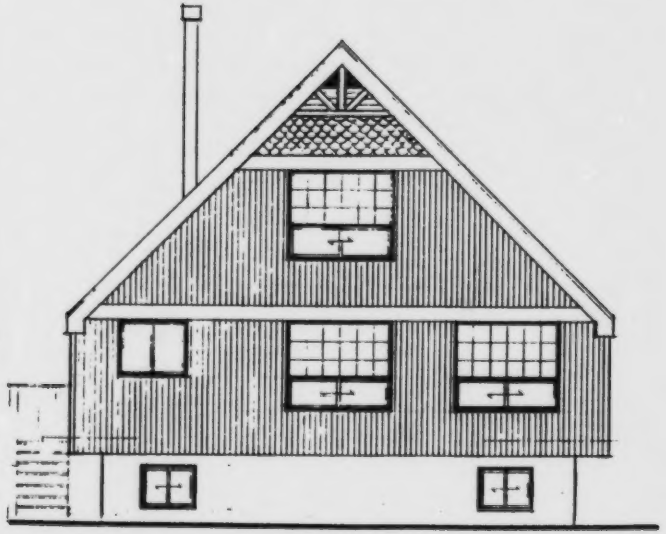


FRONT (Figure 16)

OVE 2 - PROTOTYPE SUMMARY

ROOF

- ROOF SHAPE IS SIMPLE AND STRAIGHTFORWARD, WITH THE SLOPING SURFACE ACTING AS BOTH ROOF AND WALL FOR THE SECOND STOREY PORTION OF THE HOUSE.
- ATTIC VENTING AT THE END GABLES IS MODEST, DUE TO TIGHT AIR-SEAL PROVIDED AT THE INTERIOR CEILING.

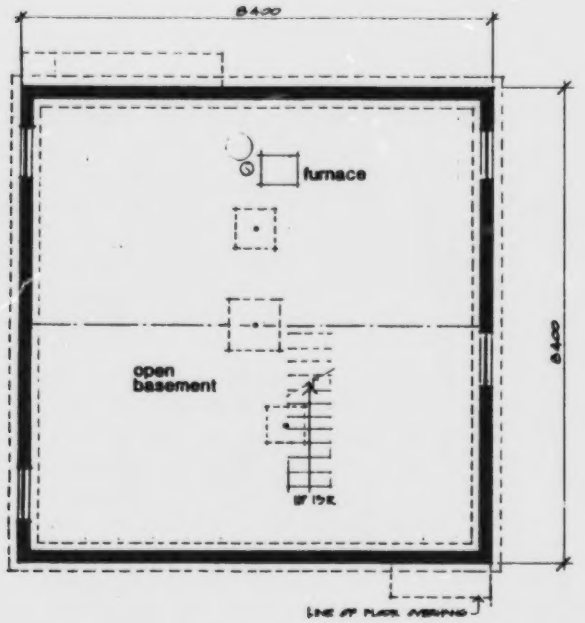


REAR (Figure 17)

OVE 2 - PROTOTYPE SUMMARY

ELEVATIONS

- EXTERIOR TREATMENT OF THE HOUSE IS KEPT SIMPLE AND UNCLUTTERED, WITH EXTENSIVE USE OF PREFINISHED COMBINED SIDING/SHEATHING AND ECONOMICAL STAINED TRIM BOARDS AT THE ROOF AND OVER WINDOWS.
- INEXPENSIVE PREFINISHED PLYWOOD "SHINGLE EMBOSSED" PANELS ARE UTILIZED AT THE GABLE-END WALLS AT THE FRONT AND BACK OF THE HOUSE.
- WINDOW SIZES AND SHAPES HAVE INITIALLY BEEN LIMITED TO THREE DIFFERENT TYPES FOR THE ENTIRE HOUSE; THIS ALLOWS FOR SIMPLER FRAMING AND LESS COSTLY VARIATIONS WHEN ORDERING. WINDOWS ARE LOCATED AT THE NON-LOADBEARING GABLE ENDS OF THE HOUSE; HEAVY LINTELS ARE NOT REQUIRED OVER THESE OPENINGS.
- FUTURE OWNER UPGRADING OF THE WINDOWS TO PATIO DOORS AT THE MAIN FLOOR COULD BE COMPLETED AT A LATER DATE, SINCE ROUGH OPENING WIDTHS ARE PROPERLY SIZED.



BASEMENT

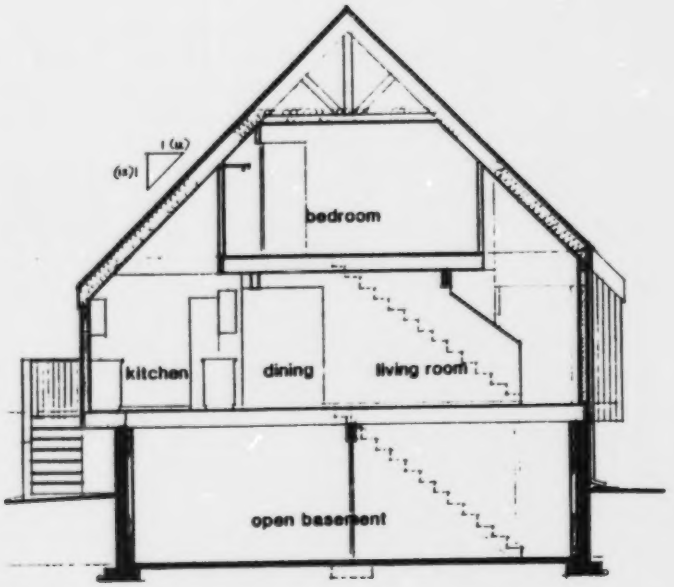
AREA : 71.64 M²
VOLUME : 170 M³

(Figure 18)

OVE 2 - PROTOTYPE SUMMARY

FOUNDATIONS

- THE BASIC OVE FOUNDATION PLAN IS AN EFFICIENT SQUARE AND IS SIZED FOR MAXIMUM USE OF MODULAR COORDINATED SHEATHING/SIDING, JOIST LENGTHS AND BEAM SPANS USED IN THE REMAINDER OF THE HOUSE.
- COSTLY JOGS AT THE FOUNDATION WALL HAVE BEEN ELIMINATED.

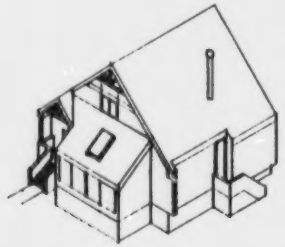


SECTION (Figure 19)

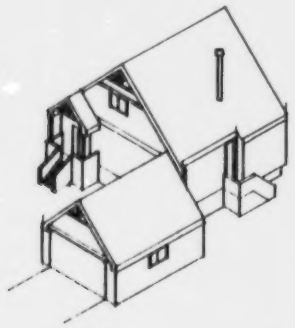
OVE 2 - PROTOTYPE SUMMARY

FOUNDATIONS

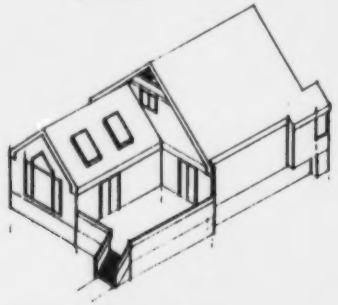
- THE USE OF EXTENDED OR 'CANTILEVERED' FLOOR JOISTS ADDS ECONOMICAL ADDITIONAL FLOOR AREA TO THE HOUSE AT VERY LITTLE EXTRA COST.
- OUTSIDE GRADE HEIGHT CAN BE ADJUSTED TO SUIT VARIYING SITE CONDITIONS; BASEMENT WINDOWS ARE SIZED FOR MAXIMUM FUTURE USE AND DEVELOPMENT OF BASEMENT SPACE INTO BEDROOMS, FAMILY ROOM, ETC.



SUN PORCH



GARAGE



FAMILY ROOM/DECK (REAR)

OVE 2 - PROTOTYPE SUMMARY

FUTURE GROWTH AND/OR CHANGE (Figure 20)

- THE BASIC HOUSE DESIGN HAS CAPABILITY FOR MODEST FUTURE EXPANSIONS AT THE FRONT, AS A VERANDAH OR HEATED SOLARIUM/PORCH AND AT THE REAR, AS A FAMILY ROOM AND DECK OR EXTENDED LIVING /DINING AREA.
- THE MAIN FLOOR BEDROOM CAN BE DEVELOPED INITIALLY AS A FAMILY ROOM OR SEPARATE DINING ROOM BY SIMPLY LEAVING OUT ONE WALL. THE MAIN FLOOR BATHROOM COULD ALSO BE MODIFIED TO DELETE THE BATHTUB AND PROVIDE ADDITIONAL COST SAVINGS.
- ONE OR BOTH OF THE SECOND FLOOR BEDROOMS COULD BE CONVERTED TO OPEN 'LOFT' SPACE AND USED AS A DEN, CHILDREN'S PLAYROOM, OR FAMILY TYPE RETREAT.

3.6 Cost Comparison Summary

As OVE techniques are an integrated method of building, maximum benefit is realized when they are all used in conjunction with each other. Nevertheless, some individual OVE methods can be integrated with conventional wood framing practice, resulting in some significant degree of cost savings.

The effect of applying OVE techniques to the average single-family home should not be to label the house as an "OVE design" in appearance or perceived quality of finishing. The goal should instead be to incorporate techniques that have been proven to be cost effective and acceptable in the marketplace.

If houses can be initially designed to include and maximize OVE techniques, cost savings should be much greater than if techniques are just applied to an existing house.

OPTIMUM VALUE ENGINEERING: COST COMPARISON SUMMARY (Table 2) LOCATION: EDMONTON - 1986

SINGLE DETATCHED DWELLING CONSTRUCTION COST ESTIMATES (INCLUDING LABOUR AND MATERIALS)

TRADE DIVISION	1986 ALBERTA HOUSE COST COMPARISON 100 SQ. METERS COST ESTIMATES	OVE 1 HOUSE 100 SQ. METERS COST ESTIMATES	OVE 2 PROTOTYPE 112 SQ. METERS COST ESTIMATES
1:EXCAVATION	$ 788	$ 788	$ 501
2:CONCRETE	5,036	4,530	3,864
3:DAMPOOFING	331	325	259
4:SIDING	2,373	2,091	2,492
5:ROOFING	992	934	835
6:CARPENTRY - ROUGH	7,390*	5,555	6,076
7:CARPENTRY - FINISH	722	221	840
8:WINDOWS AND GLAZING	1,714	1,574	1,756
9:SEALANTS	52	52	50
10:DOORS	1,019	1,019	1,400
11:HARDWARE	178	178	180
12:CERAMIC TILE	182	160	320
13:WALLBOARD	3,738	3,809	5,041
14:FLOORING	1,346	1,346	1,424
15:PAINTING	1,310	1,261	1,293
16:FITTINGS	2,289	2,048	2,268
17:SPECIALTIES	171	126	189
18:APPLIANCES	102	102	102
19:PLUMBING	2,300	2,200	2,850
20:HEATING	1,450	1,450	1,675
21:ELECTRICAL	1,533	1,533	1,683
22:SITE OVERHEAD	3,000	3,000	3,000
TOTAL/EDMONTON	$38,016	$34,322	$38,098
COST PER GROSS FLOOR AREA (M^2)	($380.16/$M^2$ GFA)	($343.22/$M^2$ GFA)	($340.16/$M^2$ GFA)

* Revised cost: Alberta Municipal Affairs (May 28/87)

3.7 STATISTICAL COMPARISONS

AHCC, OVE 1 and OVE 2 (Table 3)

Design Comparisons:	AHCC Design	OVE 1 - AHCC Design	OVE 2 - Prototype Design
Basic Quantities			
Gross Building Area: (not incl. basement)	100 square meters	100 square meters	112 square meters
Total Heated Volume: (including basement)	480 cubic meters	459 cubic meters	474 cubic meters
Total Exterior Surface Area Exposed:	245 square meters	250 square meters	311 square meters
Room/Space Sizes	**Net Floor Area**	**Net Floor Area**	**Net Floor Area**
Entrance Hall	4.4 square meters	4.4 square meters	5.3 square meters
Living Room	15.6 square meters	15.6 square meters	15.6 square meters
Dining Area	6.3 square meters	6.3 square meters	7.2 square meters
Kitchen	8.1 square meters	8.1 square meters	9.5 square meters
Master Bedroom	12.0 square meters	12.0 square meters	13.1 square meters
Bedroom #2	9.3 square meters	9.3 square meters	10.4 square meters
Bedroom #3	9.9 square meters	9.9 square meters	12.0 square meters
Bathroom	3.9 square meters	3.9 square meters	3.6 square meters
Bathroom #2 (OVE 2)	-	-	3.5 square meters
Net Useable Space:	69.5 square meters	69.5 square meters	80.2 square meters

4.0 CONCLUSIONS

4.0 Conclusions

The following conclusions may be drawn from the research work into Optimum Value Engineering techniques and the related investigation into the three cost-comparison houses:

Conventional wood-frame design and construction technology in the province have not changed appreciably over the last 20 years. There are numerous examples of materials and labour wastage in many construction projects, both large and small. In many cases much more construction material than necessary is used for reasons of perceived added structural rigidity or for assumed code compliance. In many cases the additional inputs of labour and materials serve no function and add to the overall cost of a project. Directly or indirectly, it is the housing consumer who must finally bear these significant extra costs.

Change in the Alberta construction industry has traditionally happened slowly and cautiously, and only when specific, tangible benefits could be identified for either the builder or the consumer. New approaches to construction in Alberta have been more evolutionary rather than revolutionary. Market acceptance demands that new methods or techniques must be proven to be durable. The consumer is not convinced by overly optimistic product claims or overstated savings. Alberta builders need a hands-on approach to understanding and trying the various techniques and measures proposed by the OVE concept of construction.

4.0 Conclusions

Individual cost-saving techniques proposed in the study offer the average builder a "shopping list" approach to OVE. By investigating, evaluating and trying one or more of the techniques, a builder can gradually acertain which of the measures is workable for his own particular scale and style of operation. As OVE techniques are a sequential method of building, maximum benefit is realized when they are used together. Nevertheless, many individual OVE methods can be integrated with conventional wood-framing practice, resulting in some significant degree of cost savings.

The research into OVE and non-OVE houses allows individual cost inputs into each to be analyzed, compared and contrasted. Generally, research shows the OVE 1 (AHCC designed) house achieved a total cost saving of approximately 10%.

If buildings can be initially designed to include and maximize OVE techniques, cost savings should be much greater than if techniques are just applied to an existing stock house design.

An added benefit to an all-OVE based design, such as the OVE 2 Prototype, is that design quality and market appeal can be enhanced, at the same time that cost-saving measures are being applied by a builder. This is accomplished by introducing OVE measures into the house design at the time of early planning when materials are first being selected.

4.0 Conclusions

When decisions regarding OVE techniques are applied, they can help to maximize the potential design and market acceptance of a house. There is greater potential for benefits to be passed on to both the builder and the home buyer in such a situation. In the case of the OVE 2 Prototype house, it would be possible to build a larger, better designed and more appealing house for approximately the same cost as a non-OVE house having minimal market appeal.

Cost saving building techniques put forward using the OVE approach must not be equated with "low quality" buildings. Instead, OVE must satisfy the need for more economical and durable construction techniques that are systematic and complementary to each other.

BIBLIOGRAPHY

OPTIMUM VALUE ENGINEERING: BIBLIOGRAPHY

Anderson, C. and Woodcock, D., "Nuts and Bolts", Builder, July, 1985, pp. 78-85.

American Plywood Association "Engineered 24" Framing", APA Design/Construction Guide, February, 1984, pp. 1-14.

Bent, C., "A Primer on Light Steel Framing Systems", Canadian Architect, May, 1985, pp. 36-39.

Boles, D.D., "P/A Enquiry, Affordable Housing", Progressive Architecture, February 1987, pp. 86-91.

Canada Mortgage and Housing Corporation, "Residential Site Development Advisory Document", Cat. No. NH18-2/5E.

Canadian Wood Construction, "Framing Techniques", Canadian Wood Council, 1980, pp. 1-24.

Central Mortgage and Housing Corporation, "Canadian Wood-Frame House Construction".

Energy Research Development Group, Department of Mechanical Engineering, University of Saskatchewan, "Energy Efficient Housing - A Prairie Approach", Revised 1982.

Levy, E., "P/A Technics, Industrialized Housing", Progressive Architecture, February 1987, pp. 92-95.

Luebs, D., "25 Ways to Cut the Cost of a House", Housing, April, 1978, pp. 64-67.

NAHB Research Foundation, Inc. "Building Affordable Homes, A Cost Savings Guide for Builder/Developers", U.S. Department of Housing and Urban Development publication.

NAHB Research Foundation, Inc. "Reducing Home Building Costs with OVE Design and Constrruction, Guideline 5", U.S. Department of Housing and Urban Development publication, November, 1977.

NAHB Research Foundation, Inc. "Manual of Lumber & Plywood Saving Techniques, For Residential Light-Frame Construction", U.S. Department of Housing and Urban Development publication, June 1971.